STUDIES ON SOME ASPECTS OF SERVICE QUALITY EVALUATION WITH SPECIFIC RELEVANCE TO INDIAN SERVICE INDUSTRIES

A THESIS SUBMITTED IN FULFILLMENT OF
THE REQUIREMENT FOR THE AWARD OF THE DEGREE

OF

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IN

MECHANICAL ENGINEERING

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BY

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April, 2007

Dedicated to my Guru S.N.A. Quadri
and my Parents…

CERTIFICATE

This to certify that the thesis entitled **"Studies on Some Aspects of Service Quality Evaluation with Specific Relevance to Indian Service Industries"** being submitted by **Mohammed Sadique Khan** for the award of the degree of **Doctor of Philosophy (Mechanical Engineering)** of NIT Rourkela, is a record of bonafide research work carried out by him under my supervision and guidance. Mr. Khan has worked for more than two and half years on the above problem at the Department of Mechanical Engineering, National Institute of Technology, Rourkela and this has reached the standard fulfilling the requirements and the regulation relating to the degree. The contents of this thesis, in full or part, have not been submitted to any other university or institution for the award of any degree or diploma.

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ABSTRACT

Quality has been treated as a major competing weapon by both the manufacturing industries and service providers to gain market share, improve productivity and profitability and sustain in business from long term perspective. Therefore, organizations throughout the world dealing with products or services or both are contemplating to implement Total Quality Management (TQM) principles for enhancing system effectiveness. Literature on TQM suggests that twenty critical factors ease the process of TQM implementation in any organization. However, few critical factors viz., leadership, customer satisfaction, training, and employee's participation are emphasized more frequently in the literature compared to other factors. It is also observed that standardization of the best set of principles of TQM and their implementation sequence is difficult because diverse set of TQM principles are being adopted by organizations. Exhaustive investigation on implementation aspects of TQM results in an interesting observation that adequate emphasis has not been made in the area of TQM implementation in the service sector and measurement and evaluation of service quality. In the present emerging global economy, the focus has been shifted from manufacturing to service sector necessitating the quality assessment in service sector as an important issue. The rate of adoption of TQM in service sectors is quite low because difficulty arises while quantification of service quality due to intangibility and behavioral pattern associated with it. To this end, a general methodology has been proposed in this dissertation work for assessment of quality in service sector. The methodology has been applied in two contrasting service setting such as Education and Banking. The diverse nature of requirements of stakeholders in a Technical Education System (TES) makes it extremely difficult to decide upon what constitutes quality. Hence, identification of common minimum quality items suitable for all stakeholders will help to design the system and thereby improve customer satisfaction. To address this issue, a measuring instrument known as 'EduQUAL' is developed and an integrated approach using neural networks for evaluating service quality is proposed. The

dimensionality of 'EduQUAL' is validated by factor analysis followed by varimax rotation. Four neural network models based on back propagation algorithm are employed to predict quality in education for different stakeholders. It has been demonstrated that the P-E gap model is found to be the best model for all the stakeholders. Sensitivity Analysis of the best model for each stakeholder has been carried out to appraise the robustness of the model. In doing so, not only the areas of improvement but also the minimum number of items satisfying all the stakeholders can be identified. A procedure based on Quality Function Deployment (QFD) is proposed to provide guidelines for administrators of the institutions to prioritize improvement policies need to be implemented. As aggregation of inputs and outputs of an educational system poses difficulties while evaluating quality of education being imparted, methodology based on Data Envelopment Analysis (DEA) has been proposed to rank selected technical institutions in India based on their technical efficiency score. Suggestions have been put forward for the nonconforming institutions. The result shows that significant difference exists between the conventional system of evaluation and DEA methods. It is an established fact that dimensions of quality in online services are quite different from traditional quality dimensions. To analyze the quality dimensions for online services, a case study has been undertaken to evaluate service quality of Internet banking in India from customer's perspective. Seven quality dimensions viz., reliability, accessibility, user friendliness, privacy/security, efficiency, responsiveness and fulfillment are identified based on principal component factor analysis. The result shows that customers are satisfied with quality of service on dimensions like reliability, accessibility, efficiency, responsiveness and user-friendliness but least satisfied with the dimensions privacy/security and fulfillment. The empirical finding enables the bankers to extract guidelines on service parameters where they need to improve.

***Key words**: TQM; Leadership; Customer Satisfaction; Voice of Customers; Service Quality; Expectations; Perceptions; TES; EduQUAL; Sensitivity Analysis; DMUs; Benchmarking; DEA; Internet Banking.*

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CHAPTER I

Introduction

1.1 Introduction

Business enterprises throughout the world whether involved in manufacturing of products or delivering service or both recognize quality as a major competing weapon either to improve or maintain or regain their market share. Therefore, industries are contemplating on development of innovative ways and means using quality management principles with a view to design methods and procedures so that effective control and management of quality can be assured in the pursuit of excellence. The aims and goals of a business may differ but any business enterprise must strive to identify customer requirements and produce the goods/services of right quality that excite the customers. Since 1970s, old practices of quality control like inspection activities have been replaced or supplemented by quality assurance, and presently, many organizations sincerely works towards Total Quality Management (TQM) [1]. Two distinctive features of TQM that differentiates it from earlier practice of quality management are: - (i) it embraces the whole organization instead of simply focusing on parts of the product or service; (ii) it brings about cultural change in the organization rather than focusing on large investment on assets. Service sectors happen to account for more than 75% of the GDP in developed countries and currently, the same trend is being observed in most of the developing countries [2]. An extensive literature survey of a series of research articles studied for the purpose of this dissertation from various journals related to TQM and its implementation pattern, both in manufacturing and service sector indicate an interesting trend that only one-fifth of the articles are related to service sector out of the total number of articles studied [3]. Low rate of adoption of TQM principles in service sector may be attributed to difficulty in measuring and evaluating service quality because behavioral aspects are involved in delivering service. Measurement and evaluation of service quality, two important aspects of TQM implementation in an organizational context, are largely influenced by the expectations and perceptions of customers because they are directly involved in the process of delivery of service. In addition, type and size of service setting and internal and external factors of the organization greatly influence service quality.

Therefore, it becomes practically inconvenient to set the standards and procedures for measuring and evaluating service quality. Further, in a multi-stakeholder situation, the prospective customers or stakeholders interact with the service provider in many ways with different set of mind of expectations (before service) and perceptions (after service). Moreover, service comprises of too many items (or characteristics) and these items widely differ across the industries. Hence, it is desirable to develop a comprehensive methodology to enable the managers to design an instrument consisting of service dimensions and items for systematic assessment of service quality. To this end, in this dissertation, attempt has been made to provide a general framework for designing the service instrument suiting most of the stakeholders and evaluation methodology for identification of bottlenecks existing in the system. The proposed evaluation methodology has been applied in two different but important service sectors such as 'Education' and 'Banking'. The reason for choosing these sectors lies in the fact that they not only contribute largely on socio-economic development of a developing country like India but also they contrast each other as far as their operational objectives are concerned. 'Education' is primarily treated as philanthropic service whereas 'Banking' is viewed as a profit making service.

As far as measurement of service quality is concerned, different instruments have been proposed for measuring service quality in a convenient manner. However, 'SERVQUAL' and 'SERVPERF', two important service quality measuring instruments are widely used in the literature as well as industries because of their generalization capability [4,5]. But, the dimensions and items of these instruments are being modified time-to-time depending on purpose and applicability in a particular service setting. Cui et al. has demonstrated, through a confirmatory factor analysis applied to banking sector, that both the measuring instruments lack validity in Asian markets. It has been proposed to modify these instruments by reducing the number of dimensions covering almost all original items [6]. Abdullah has proposed a measuring instrument called 'HEdPERF' for measuring service quality in higher education sector and compared with

‘SERVPERF’ [7]. A self-developed construct for assessing customer requirements has been developed by Sahney et al. [8]. The instrument is used to compare technical and management institutes. Based on the perceptions of the visitors, an instrument known as ‘DIVEPERF’ containing twenty-seven quality items, has been proposed for dive tourism industry [9]. The conceptual framework for understanding the inter-linkages among service quality and various components of the company-customer perspective has been proposed by Parasuraman [10]. Jensen and Markland describe how different services have different emphases in the elements making up quality using the instrument SERVQUAL [11]. Chow et al. have used SERVQUAL with some modification to measure the service quality in a fast-food restaurant [12]. However, development of measuring instrument and evaluation of service quality have been addressed as two distinctly separate problems in the literature rather than emphasizing on an appropriate integrated approach to pursue quality improvements acknowledging valid guidelines. In manufacturing sector, quality measurement and evaluation proceeds in a parallel fashion but it moves in a sequential manner in service sector. Therefore, it necessitates use of an integrated approach of assessing service quality in which both development of measuring instrument and evaluation of service quality can be presented in a systematic manner so that insights to the quality related the service providers could obtain problems. Hence, a comprehensive approach has been depicted in Figure 1.1 in the form of a spiral of quality providing a general methodology for assessment of service quality in accordance with spiral of quality proposed by Juran for manufacturing quality [13].

It is evident from Figure 1.1 that evaluation of service quality requires a robust instrument for measurement after thorough understanding of customer needs. The evaluation procedure not only facilitates system design and implementation of quality planning activities but also provides guidelines to improve upon in certain quality dimensions so that expectations of the customers can be fulfilled. The broad quality improvement strategy has been applied to

education sector, particularly technical education, considering interactions of various stakeholders with Technical Education System (TES).

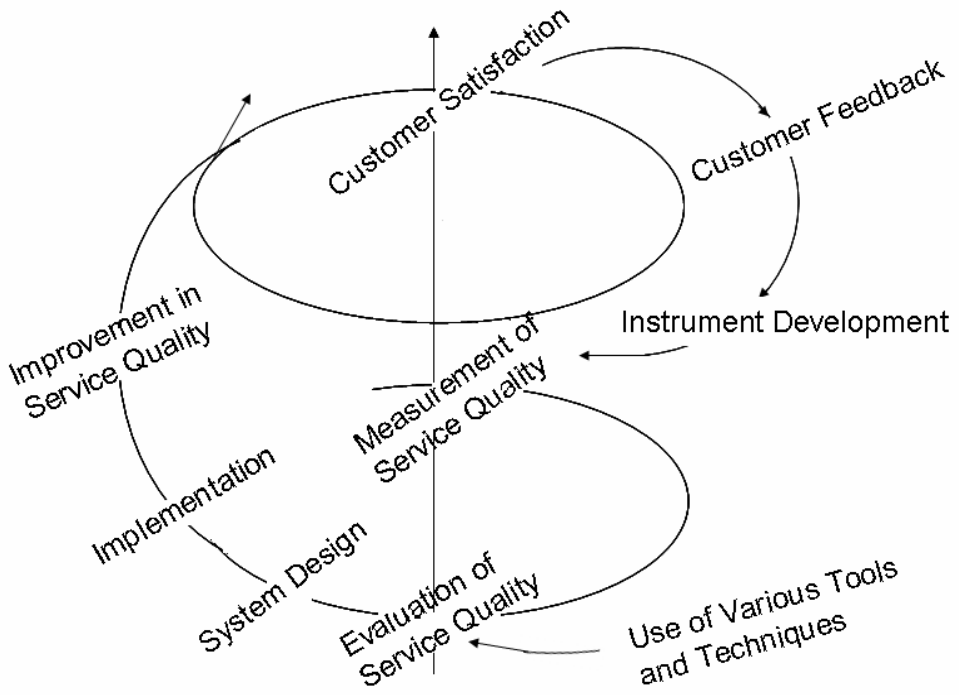


Figure 1.1: Spiral of Progress of Quality in Service Quality

Application of proposed quality assessment methodology enables to identify a common minimum number of service items in TES fitting to all important stakeholders for facilitating the administrators to devise methods, procedures and policies that have bearing on improvement on satisfaction level of the stakeholders. As the service quality in Internet banking is completely different from that of the conventional banks in respect to interaction of bank and the customers (because human interaction is completely absent in Internet banking), it requires some special kind of service quality improvements. A conceptual framework for quality assessment in Internet banking in relation to customer and provider's perspective has been proposed.

Various tools and techniques such as statistical methods, statistical process control (SPC), multi-criteria decision making methods like Analytic Hierarchy Process (AHP), Artificial Neural Networks (ANN), fuzzy logic, Fuzzy-AHP, rough sets, Quality Function Deployment (QFD), optimization techniques like Data Envelopment Analysis (DEA) have been employed for evaluation of

service quality so that quantitative evaluation of qualitative nature of service items can be made in an effective manner [14-18]. Some of the traditional techniques viz. statistical methods and SPC suffer from major drawbacks in real-world scenario due to their inability to capture nonlinear coherences that need consideration of imprecision and vagueness. In order to alleviate these problems, different soft computing techniques have found increasing consideration in practice promising effective and efficient solutions for evaluation of quality in service sectors [19]. Among the various techniques, neural networks have been frequently applied as it has the capability to predict an output (human decision), classify a given set of inputs into different groups (known as the pattern recognition), and incorporate heuristic criteria [20]. As neural network can effectively exploit and represent the non-linear relationship between the consumer satisfaction and their perception of the service, it can be used for modeling of a customer's decision-making process [21]. Hoefer and Gould have used a neural approach to predict students' academic performance in business programme [22] whereas Nordmann and Luxhoj applied for forecasting of service problems in aircraft structural component grouping [23]. Tam and Kiang applied a neural approach for predicting failures in banking sector [24].

1.2 Importance of Quality

Quality has been viewed in many ways by different proponents of quality [25-29]. However, the holistic definition of quality suggested by American Society for Quality Control (ASQC) is frequently adopted. According to ASQC, quality is defined as the totality of features and characteristics of a product or service that bears on its ability to meet a stated or implied need [30]. Generally, quality studies in an organizational context aims at improving quality, reducing cost, capturing the market and staying in business. Although industries use competitive weapons like cost, productivity, quality and time in an orderly fashion to gain edge over others, strategies leading to improve quality are vital for enhancing system performance in manufacturing as well as service organization to match with ever increasing competitive environment. Traditionally, it is

believed that quality and productivity are of conflicting in nature but presently synergy between quality and productivity is desirable for organizational success because both lead to same goals (i.e. waste minimization). However, implementation of TQM is the convenient way of developing company-wide quality consciousness.

Any organization interested to implement TQM finds it hard to obtain a generalized strategy of implementation because sequence of implementation of TQM tools widely differs among types of industries and organizations within an industry type [31-36]. However, several researchers have attempted to identify and categorize the different stages associated with quality improvement. Amitav Mitra broadly divides the process of TQM implementation into three stages such as commitment, consolidation and maturity stage of quality improvement [2]. In ***commitment stage***, management makes a commitment to the quality improvement program by developing a plan and policy and an organizational structure to implement the plan that includes adequate education and training of the personnel. In the **consolidation stage**, the objectives are fixed to produce an item that conforms to requirements and to start a continual improvement in the efficiency and productivity of the process. Education and training are an integral part of this stage. Managing the conforming and non-conforming products is the key to successful implementation of this phase. During **maturity stage**, the process parameters are adjusted to create optimum operating conditions. Very few defective products are produced and therefore, efforts are made to defect prevention and cost reduction.

1.3 Quality of Product and Service

In manufacturing industries, measurement and evaluation of product quality becomes easy because quality is defined as the variation in predetermined specifications. The process standards for manufacturing firms are relatively easy to specify and can be analyzed using different quality improvement tools because manufacturing sector makes products that are tangibles. For example, a cylinder is to be manufactured with a specification on

length of 100 ± 5 mm. Using a goal-post approach, it can be accepted as a good quality item if the length is less than 105 mm or greater than 95 mm. If the length is either more than 105 mm or less than 95 mm, the cylinder can be treated as bad quality product. On the other hand, service sectors have intangible components associated with them. It is a combination of technical and human behavioral aspects that is extremely difficult to quantify e.g. quality of food in a restaurant, quality of facilities in a hotel, or quality of education in an educational institution. When demand for a product exceeds the available supply, it might be possible to back-order excess demand in manufacturing industries. This, however, is not possible in service industries. Most service functions have a time constraint associated with them. If the service is not provided within required time, it cannot be used at a later time. For example, if a seat in a bus is vacant between 7 AM to 8 AM, this empty seat cannot be saved for using during the rush hour of 10 AM to 11 AM.

The involvement of both producer and consumer is absolutely essential in the process of delivery of service. For example, the doctor or a nurse in a hospital has to interact with the patient, who is a consumer, for quality diagnosis of the disease. Responses from the patient may influence the quality of service delivered to the consumer. In manufacturing industries, the producer alone influences the process through which the product is made. However, the consumer in the manufacturing industries influences the product during the design phase of the product to incorporate various product features as per their requirements. Once product and process is designed satisfactorily, the consumer does not have any role to influence the product quality during production. Another important characteristic of service industry is that services cannot be resold whereas manufacturing products can be resold. As behavioral aspects are associated with the service sector, evaluation of service quality becomes extremely difficult. If a customer is dissatisfied in a service, it is difficult to identify exactly which characteristics of the services are to be blamed. Table 1.1 shows some of the basic difference between manufacturing and service sector.

Table 1.1: Difference between Manufacturing and Service Sector

Manufacturing sector	Service sector
1. In manufacturing sector the products are tangible	1. In service sector products are generally intangible.
2. Back orders of components are possible in manufacturing sector.	2. Service cannot have any inventory. It cannot be stored if not used they are lost.
3. Producer is the only party involved in the making of the products in manufacturing sector.	3. Both Producer and consumer are involved in the delivery of the service
4. Product can be resold.	4. Service can not be resold
5. Specifications determines the quality of manufacturing product	5. Quality of service is difficult to quantify due to behavioral component associated with it.

1.3.1 Characteristics of Service Sector

In order to characterize services, it is not enough to say simply that they are intangible acts as opposed to tangible goods. Most modern products are a combination of both. For example, when purchasing a washing machine the customer also receives services such as installation, maintenance and repair. When getting a haircut, the customer will likely also benefit from a number of hair care products and might even purchase some for home use. In order to provide a satisfactory definition of services, it is desirable to look into the various characteristics of important features of a service [37-39]:

- ***Intangibility*:** services cannot generally be seen, tasted, felt, heard or smelled before they are bought.
- ***Inseparability*:** services are produced and consumed at the same time.
- ***Variability*:** the quality of the same service may vary depending on who provides it as well as when and how it is provided.
- ***Perishability*:** services cannot be stored for later sales or use; producing to an inventory cannot even out lack of demand.

One of the most important distinction from which all other differences arise is the property of **intangibility**. Service industries create economic value without

creating a tangible product, as they do not have any product with exact specifications. Services are usually performance rather than objects and consumed during the process of delivery. Therefore, it is difficult on the part of supplier to describe, explain and specify how the consumers perceive their services and how to evaluate service quality and even assure quality.

Goods are first produced, sold and then consumed any time whereas services are first sold then produced and consumed at the same time. This is expressed as the characteristic of **inseparability** of production and consumption of service. Therefore, service providers have to be prepared to deliver the service in front of the customer at the moment of consumption. The employees, the service providers, the physical conditions, aesthetic sense and the surroundings of service facilities play a vital role to satisfy and delight the customer.

The perception of service quality varies in different service sector. Even the same service provided by different producers has different perceptions of quality by the customers. The services also vary from time to time at the same place. For example, the quality of food provided in a restaurant in the morning may not be same that is provided in the evening. This is known as the **variability** feature of the service sector.

Another distinguishing characteristic is that services are produced and consumed at the same time that causes elimination of inventory. This characteristic is called **perishability** of service. Service industries cannot pile up services or cannot have inventories to overcome the peak demand.

Apart from above features of service, it is important to highlight some behavioral characteristics of service quality that will help to design and monitor services [2];

- Human Factors and Behavioral Characteristics.
- Timeliness Characteristics.
- Service Non-conformity Characteristics.
- Facility- Related Characteristics.

Human Factors and Behavioral Characteristics: Service quality is largely influenced by the attitude and behavior of the provider [37, 40-42]. Since

providers and customers are part of product or service, their behavior affects the quality of service. To improve the quality of service, the human factors such as eagerness to help, thoughtfulness, complacency and courtesy must be developed through proper training of employees. As far as customer behavior is concerned, it is beyond the control of company providing the service. The expectations and perceptions of customers greatly influence the quality of services.

Timeliness Characteristics*:* Timeliness characteristics of a service associate with providing service within a specified span of time. Service that is not used during specified time cannot be stored in future. For example, empty beds in a Hospital during certain days of a month cannot be saved for use in the latter month. The factors such as time to order the service, the waiting time before the service is performed, the time to serve and the post-service time are significant for customer satisfaction and service quality improvement.

Service Non-conformity Characteristics: This characteristic highlights the variation in providing service from a specified performance level i.e. non-conformity of service from its ideal level. For example, number of errors in processing per 100 vouchers by bank employees and the number of data entry errors per 1000 keystrokes by a data entry operator, the number of complaints per 100 guests in hotel, represents non-conformity characteristics. For improvement of service quality and customer satisfaction, non-conformities (errors) must be eliminated completely.

Facility-Related Characteristics: Customer satisfaction is also influenced by the physical characteristics of the facilities associated with a service and its delivery. For example, an uncomfortable bed in a hotel room, unavailability of a swimming pool in a hotel, insufficient leg room in an aircraft, shabby appearance of a receptionist in a hotel or bank and lack of internet facilities in an educational institute cause deteriorate service level.

1.3.2 Classification of Service Sector

It is not easy to classify service sectors in a useful manner due to variability or heterogeneity characteristic of service. However, the classification proposed by Lovelock is worth mentioning because it considers almost all important aspects of service from the people's everyday life [37, 43]. According to this classification, the services are divided into four categories such as (1) Tangible actions directed at people's bodies (2) Tangible actions directed at goods and other physical possessions (3) Intangible actions directed at people's minds and (4) Intangible actions directed at intangible assets.

Table1.2: Types of Service Sector

Sl.No.	Types of services	Examples
1	Tangible actions directed at people's bodies.	Health care Passengers Transportation Hotels and Restaurants Beauty care
2	Tangible actions directed at goods and other physical possessions	Freight transport Industrial equipment Repair and maintenance Janitorial services Laundry and dry cleaning Veterinary care
3	Intangible actions directed at people's minds.	Education Broadcasting Information service Theatres Museums
4	Intangible actions directed at intangible assets	Banking Legal services Accounting Securities Insurance

Table1.2 shows different types of service sectors with examples. Service quality assessment approach proposed in this dissertation work has been applied to two important sectors such as education and banking belonging to category 3

and four respectively of Table 1.2. Therefore, a brief scenario of these sectors has been highlighted in regard to prevailing quality assessment practices in these sectors with specific relevance to Indian organizations.

1.4 Quality in Education Sector

Education in India may be divided into two types – primary education dealing with basic education and higher education in three streams like science, technology and humanities. The advent of new technologies generates requirement of a large number of technical manpower for a developing country like India. Over a period of three decades, a well-organized structure and a wide network of technical institutions offering different types of programmes such as craftsman courses, technician (diploma) courses, graduate and post- graduate courses catering to the needs of various levels of knowledge, skills and competences have come up. Today, many engineering colleges and technical universities with various course structures compete with each other as well as with the foreign institutes for imparting quality education. All India Council of Technical Education (AICTE) registers 1,346 numbers of engineering colleges in different parts of the country with an intake capacity of 43, 9,689 in different branches of engineering and technology till 2004. Limited number of state funded institutions and diminishing funding in higher education by government caused mushrooming of private institutions in India. Therefore, the students have wide option to choose the institution to pursue their interests. As the students bear the complete expenditure of education, they deserve the best education. Therefore, quality has become a competing weapon for the institutions to serve and retain their primary customers (students).

The concept of quality when applied to higher education is still not well defined. Definitions of quality in education follow the general definitions of quality. The term has been defined in many ways like “excellence in education” [44], “value addition in education” [45], “fitness of educational outcome and experience for use” [46], “defect avoidance in the education process” [26], and “meeting or exceeding customer’s expectations of education” [47]. Variations in

conceptualizations of quality in education pose extreme difficulty in formulating a single and comprehensive definition. Moreover, educational services are intangible, heterogeneous, and inseparable from the administrator's point of view whereas it is variable and perishable for the customers' viewpoint. Further, in this highly competitive environment, students have become more discriminating in their selection and more demanding in regard to choosing colleges and universities. It is also important for the institutions to understand what the incoming students expect from the institution of their choice. Therefore, the issue of survival of the institute and the retention of the students has become an area of critical concern for most colleges and universities [45,46]. To address these issues, the administrators of the educational institutions should focus more on improvement of overall quality of education through continuous improvement programmes.

Improvement of quality in higher education has attracted the attention of researchers over the years for developing methods and procedures for assuring quality in higher education. Owlia and Aspinwall interpreted the quality for higher education in terms of the quality dimension using Garvin's quality framework, service quality dimension by Parasuraman et al. and software quality dimension by Watts [25,48-50]. However, the dimension identification framework focuses mainly on defining the quality aspect of the product features and service features [25,51,52]. A more comprehensive approach to classify the quality attributes in higher education was proposed by West et al. [51]. This is called the Input–Process–Output (IPO) framework in which 'Input' refers to the entry requirements, 'Process' refers to the teaching and learning process, and 'Output' refers to the employability and academic standings (Figure 1.2). Such classification of quality attributes resemblances with the organization's operation system of converting the inputs (e.g. raw materials) into outputs (e.g. products and services) via the process (e.g. procedures). In this way, one can associate the quality improvements with the operating system of any organization including those from the education sector.

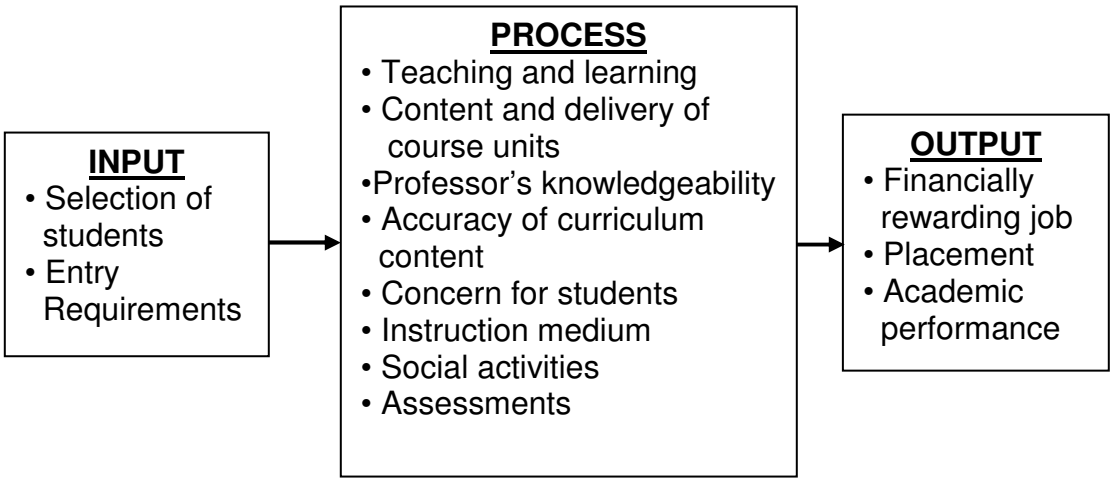


Figure 1.2: The Input–Process–Output framework of quality classification In Education System

1.5. Quality in Banking Sector

The Indian banking system today has been transformed into a technology intensive and customer friendly model with a focus on convenience. The increased volume of activity that banks go through on a daily basis demands the attention of quality control and improvement procedures. Although automation has helped banks perform their functions in a quick and timely manner, the risk of errors has also increased. Customers expect an error free performance. Human factors and behavioral characteristics such as courtesy, contact and communication are quite important as they have a major impact on customer satisfaction. Timeliness characteristics such as the waiting time and transaction processing time are also of concern. Perfect accuracy is expected as far as service non-conformity characteristics (such as errors in transactions) are concerned. The above problems can effectively be solved through adoption of e-banking, particularly, the Internet banking.

The term Internet banking refers to retail banking carried out by a customer using an Internet-based banking application such as managing accounts, pay bills, transfer funds, invest and disinvest, with a personal computer and web-browser. The customers usually get a wide choice of services available in the websites at competitive costs. They try to switch over between the

competing providers of services wherever they find better facilities. Therefore, it is of prime importance that the Internet banking is to be continually improved to provide better services to the customers for their retention.

However, comparatively less literature is available in the area of service quality studies related to Internet baking. Joseph et al. investigated the influence of Internet on the delivery of banking service [48]. They have categorized six underlying dimensions such as convenience and accuracy, feedback and complaint management, efficiency, queue management, accessibility and customization as e-banking service quality dimensions. Jun and Cai identified seventeen service quality dimensions of Internet banking service quality and pointed out that few dimensions like responsiveness, reliability and accessibility are critical to both traditional and Internet banks [52]. A qualitative research approach carried out in UK reveals that the dimensions important to the online banking customers are reliability, efficiency, responsiveness, assurance, ease of use and information [53]. Jayawardhena transforms the original SERVQUAL construct into the Internet context and develops a battery of twenty-one items to assess service quality in e-banking. By means of an exploratory (EFA) and confirmatory factor analysis (CFA), the twenty-one items are condensed to five quality dimensions viz., access, web site interface, trust, attention and credibility [54].

Internet banking in India is currently at a nascent stage. While there are scores of companies specialized in developing Internet banking software, security software and website designing and maintenance, there are few on-line financial service providers. Industrial Credit and Investment Corporation of India (ICICI) Bank is the first one to have introduced internet banking for a limited range of services such as access to account information, correspondence and recently, funds transfer between its branches. ICICI is also getting into e-trading for offering a broader range of integrated services to the customer. Several finance portals for provision of non-banking financial services, e-trading and e-broking have also come up. Therefore, comparatively less number of studies in the area of service quality evaluation in India inspired us to concentrate on the

dimensions of Internet banking pertaining to its present status and providing guidelines to the bankers for improving the service quality in Internet banking.

1.6 The Need for Research

'SERVQUAL' (and its modified versions), a multiple-item survey instrument, that supports qualitative analysis with quantitative information are still popular among researchers as far as assessment of service quality is concerned and have been successfully applied to different service sectors [4,55-57]. The instrument uses five core criteria (dimensions) consisting of twenty-two pairs of components evaluated in a seven point Likert-type scale under which customers decide in evaluating the service quality. SERVQUAL-based gap model (popularly known as Perception minus Expectation or P-E gap model) has been effectively used for assessing quality practices for providing guidelines for improvements [58-60]. However, poor reliability and inter-factor correlations of 'SERVQUAL' leads to propose 'SERVPERF' (perception-only model) and 'HEdPERF' (Higher Education PERFormance) for efficient measurement of service quality in general and education in particular [5,7]. In addition to popular P-E gap model, two more models such as expectations minus perceptions (or E-P gap model) and expectations and perceptions (E&P) model have been proposed to take care of the preconceived expectations of customers before the service is being delivered [61]. The study also demonstrates that neural networks based on back propagation algorithm can effectively be used for modeling and evaluating qualitative and intangible aspects of service quality. An extension of 'SERVQUAL' to the online service quality has been suggested by Zeithaml, et al. known as 'e-SERVQUAL' in which dimensions like efficiency and fulfillment and privacy are specific to the online service quality [62]. Many researchers have proposed dimensions for measuring online service quality considering the types of service encountered and the demographic conditions of the service [63-69]. Statistical and soft computing tools and techniques are also frequently used by the researchers for successful evaluation of service [11,14-18,22-24,70].

In general, research articles on service quality address two types of problems viz. **instrument for measuring service quality** and **evaluation of service quality** in separate framework of study indicating that it is highly desirable to incorporate both the problems in a comprehensive manner. To this end, a conceptual general methodology for measuring and evaluating the service quality has been proposed as shown in Figure 1.1. Two testing beds distinctly different from each other such as 'Education' and 'Banking' that have strong effect on the social and economic development of a country have been used to validate the models and extract complex underpinnings of service quality. Education sector represents a multi-stakeholder situation with intangible actions directed at people's minds whereas Internet banking is characterized as Intangible actions directed at intangible assets. Moreover, operational objectives of both the sectors differ widely in the sense that 'Education' is primarily treated as a beneficiary service whereas 'Banking' is viewed as a profit making service at least in Indian context. Two sectors also differ as far as interaction of the customer in the process of service delivery is concerned. In education sector, the customer directly interacts with the system while customer interacts with the system in an indirect way through website in Internet banking. Further, the customers in education sector are not well defined as dilemma of treating students as products or customers is not yet resolved. Banking sector, on the other hand, has well defined customers. These are some of the reasons why the measuring instruments and the dimensions within each instrument necessitated for measuring service quality in two contrasting sectors differ to a large extent. For example, the dimensions like 'Privacy/Security' and 'Efficiency' are more critical in Internet banking whereas 'Responsiveness' and 'Academic Reliabilities' are essential in education sector.

Higher education in general and technical education, in particular, represents too process oriented, intangibility and multiple stakeholder situations. Most of the performance measurement systems of higher educational institutions do not reflect the full range of interested parties (stakeholders) and are not closely linked to the strategic management. Therefore, some researchers have

proposed the use of a balanced scorecard approach in order to reinforce the importance of managing rather than just monitoring performance [48]. Rapert et al. confirm the importance of expectation of key stakeholders in the educational process while exploring the meaning of quality through students' evaluation of an MBA program using a combination of qualitative and quantitative approach [71]. Temponi analyses the main elements of continuous improvement in higher education addressing to the concerns of academia's stakeholders during the process of its implementation [72]. Lomas emphasised on selection of particular quality management model such as EFQM (European Forum for Quality Management) and TQM (Total Quality Management) for promoting continuous improvement of quality in education [73]. In addition, few studies highlight the method of pedagogy and selection of institutes of higher learning [74,75].

In view of the above needs, several objectives are set to carry out investigation and research in this thesis. These objectives are summarized in the following section.

1.7 Objectives of the Research Work

Due to the intangible characteristics of service, the measurement and evaluation is quite difficult. The literatures show that the instrument development and evaluation have been addressed separately indicating a need to integrate them in an orderly fashion. Questionnaire survey is generally used to develop the instruments for measuring service quality. On the other hand, evaluation of service quality has been achieved applying various tools and techniques such as ANN, QFD and DEA for improvement of service quality and subsequent recommendations to the service providers.

Several applications of ANN have been made by researchers in service sectors including education to exploit the non-linear relationship between the consumer satisfaction and their perception of the service [22-24,75-86]. As human decision-making process can be modeled using neural networks, it can be used for modeling of a customer's decision making in an effective manner [61]. Moreover, various researchers to assess customer satisfaction have

successfully used several other techniques like AHP, Fuzzy-AHP, Analytical Network Process (ANP) and Goal Programming [12,16,87]. But these techniques have some specific drawbacks also. For example, AHP can accommodate seven attributes at a time in each level of the hierarchy. But, generally, the customer requirements in any service sector may contain large number of variables that brings about a lot of problems in interpreting the customer requirements. However, tools like QFD and DEA have been suitably employed in the literature for decision-making process in service sectors. QFD is used to frame policies for quality improvement by specifying customer needs and translate them into product designs through a structured and well-documented framework [88-108]. Similarly, DEA is an approach for comparing the relative efficiency of Decision Making Units (DMUs) in a multiple inputs and multiple outputs situations such as education because direct comparison of DMUs is generally difficult due to multiple input-output nature of education sector [109-119].

Therefore, the major attention of this research work is focused on development of an integrated approach for evaluating service quality with specific relevance to Indian environment. The followings are the principal objectives of this research work:

1. Design of an instrument 'EduQUAL' for service quality measurement in Technical Education System (TES) in India by considering the responses from important stakeholders such as students, alumni, parents and recruiters.
2. Modeling of customer evaluation of service quality applied to TES considering four neural network models such as P-E gap, P-only, E-P gap and E&P in order to specify the best model because non-linear relationship between the consumer satisfaction and their perception of the service can be conveniently treated with neural networks [5,47,61]. Sensitivity analysis for the best model is essential for identification of the deficient items suggested by all four stakeholders for providing guidelines to the policy makers.

3. A framework for system design needs to be established for TES using QFD technique so as to enable the policy makers to design the system for providing services that suits customer expectations.
4. Benchmarking is one of the important aspects of TQM because it enables to identify efficient Decision Making Units (DMUs) and helps to frame strategies by the policy makers for improvement of the efficiency of the inefficient DMUs. Using the instrument 'EduQUAL', the technical institutions in India needs to be evaluated so that most efficient institutes as far as quality of education are concerned can be found out. In this regard, Data Envelopment Analysis (DEA) is a suitable tool for the purpose of finding out efficient DMUs. However, most of the DEA studies use quantitative input and output measures neglecting qualitative behavioral aspects of service quality. Since the nature of non-linear relationship between the consumer satisfaction and their perception is not exactly known, it may be relaxed to fit the problem in DEA paradigm. Considering the above facts, expectations and perceptions are used as inputs and outputs to DEA model to identify efficient DMUs.
5. The thesis also explores the service quality of Internet banking functioning in India from customer's perspective. Since research on service quality in Internet banking is still in its infancy stage and relevant literature is scarce, the insight gained in this study may offer a foundation for future research on self-service technology and provide useful recommendations to the bankers for improving the Internet banking service.

1.8 Organization of the Thesis

The remaining part of this thesis is organized into seven chapters. A chapter wise summary is given below:

Chapter II

This chapter presents a general review of the literature available on quality philosophy. Various approaches of Total Quality Management (TQM) proposed

by different quality gurus are briefly discussed. Literature related to TQM and its implementation pattern has been studied both in manufacturing and service sector. Literature survey points out an interesting trend that only 21% of the articles out of the total number of articles studied are related to service sector. Therefore, there is a need for an extensive research in the area of quality in service sector. Review of literatures concerning the traditional service quality, e-service quality, dimensions of traditional and online service quality and the various types of service quality models has been covered.

Chapter III

Measurement of a service quality is extremely difficult due to involvement of human behavior of stakeholders and association of intangibility factors. This chapter describes a detailed methodology to develop a service-measuring instrument, known as 'EduQUAL', suitable for an education sector. Since education sector exhibits multiple stakeholder situations in which stakeholders perceive different opinions in regard to quality of education, the generalized service quality measuring instrument like 'SERVQUAL' and SERVPERF' could not be effectively used to evaluate the service quality in education. Therefore, considering 'SERVQUAL' as a base, an instrument for measuring service quality in TES, known as 'EduQUAL', is developed. It consists of five dimensions comprising of twenty-eight relevant quality items. The reliability and validity of the instrument have been tested. In the next section, the relative significance of 'EduQUAL' dimensions for important stakeholders viz., students, alumni, parents and recruiters are studied in detail to get deeper insight into the quality in a TES.

Chapter IV

In this chapter, a methodology for evaluating service quality in technical educational institutions in India using 'EduQUAL' has been discussed. The methodology uses back propagation algorithm of neural network to the data obtained from important stakeholders through a questionnaire survey. A brief description of ANN has also been presented. Four neural network models,

namely, P-E gap, P-only, E-P gap and E&P models have been used in this study to find out the best model suitable for TES.

Chapter V

This chapter provides guidelines for the administrators of TES to implement continuous improvement strategies in educational institutions keeping in view of all the stakeholders. Administrators must prioritize the needs and requirements of the stakeholders considering the importance of the service quality items because it is not possible to implement the requirements of all stakeholders at a time. To address this issue, this chapter demonstrates how QFD technique can be used for decision-making process.

Chapter VI

This chapter describes how Data Envelopment Analysis can be used for finding out the benchmarking technical institutions in India. The literature related to the application of DEA in higher education is covered. Subsequently a case study has been carried out for ranking of Indian technical institutions. The analysis considers two types of DEA models viz., CRS (Constant Return to Scale) and VRS (Variable Return to Scale).

Chapter VII

This chapter considers distinctly different service sector from education viz., Internet banking. A methodology for assessment of quality of service in Internet banking using the customers' expectations and perceptions has been demonstrated. Literature review of Internet banking in India as well as in the other countries has been carried out to develop a conceptual framework measuring the service quality in Internet banking. In the next section the research methodology for the development of the measuring instrument has been proposed. Finally, the results are statistically analyzed and conclusions are drawn.

Chapter VIII

This chapter presents the summary of the conclusions, recommendations and scope for future work in the area of quality measurement in service sectors. This chapter also discuses the specific contributions made in this research work and the limitations.

The thesis ends with a list of references and a set of appendices.

CHAPTER II

Literature Review

2.1 Introduction

The traditional Statistical Process Control (SPC) techniques, first proposed by Shewhart in 1931, are still widely used in manufacturing as well as service organizations. However, publication of Juran's famous "Quality Control Hand Book" in 1951 led to diversify the basic quality control theory into various pertinent areas viz., supplier management, employee involvement, team work, leadership, customer focus, service and strategic planning. At the same time, the Japanese, inspired by the lectures of Deming and Juran, adopted the principles of TQM with a view to gain competitive edge in the international market for reviving their economy. In the last few decades, significant increase in research on TQM led to documentation of large volume of research articles, case studies and survey results. Majority of these articles focus on benefits derived through application of TQM in different organizations. However, few articles suggest that TQM has failed in some organizations [120]. The reasons for failure are largely attributed to inflexibility in the system and negative publicity. In spite of failure in few organizations, widespread implementation has been observed in manufacturing as well as service sectors. In this context, several models of quality for successful TQM implementation have been developed by various researchers [36,38,44-46] both in academics as well as industries. Juran's Trilogy, Crosby's 14-point program, Deming's Chain Reaction, Malcom Baldrige National Quality Award, European Quality Award model and ISO 9000 Series are few remarkable guidelines on TQM. The researchers mainly focused on specific critical factors adopted in different manufacturing and service industries. The literature survey of articles published in the last decade shows that a wide range of critical factors has attracted the attention of the researchers. Interestingly, the set of critical factors considered and their complementation sequence widely vary across different types of industries. For example, customer focus and satisfaction, strategic planning, top management commitment, social impact, human resources management, training, employees' participation is considered as best bundle of concepts for TQM implementation in one application [121-129]. In another application, the set of concepts consisting of quality assurance, zero

defects, quality culture and quality system is considered as best set of techniques. This anomaly leads to difficulties in selecting the right choice of a set of TQM ideas suitable for a specific situation. In addition, process management and its control and product/service design and control are also heavily emphasized in literature for successful implementation of TQM in an organization. Few important factors like strategic planning and supplier management are given adequate coverage in TQM literature whereas factors such as benchmarking, zero defects, quality assurance, quality culture, quality system are given relatively less coverage [130-132]. However, TQM must be viewed as an integrated philosophy rather than a piece-meal approach. Furthermore, implementation of a single or a set of ideas may not result in significant improvement of quality of product/process. Now-a-days implementation of TQM is absolutely essential in both manufacturing and service firms to excel in the business. Although TQM originally initiated in manufacturing firms but gradually gleaned into service sectors. Mahapatra and Khan have analyzed two hundred fifty six articles published during 1994-2004 related to TQM implementation both in manufacturing and service sectors through a suggested TQM construct consisting of twenty critical factors [3]. Finally, the authors concluded that only twenty one percent articles out of total number of articles referred in this study relates to service sectors. Relatively less adoption of TQM in service industries may be due to difficulties arising in measuring and evaluating service quality. Therefore, there is a need to concentrate on devising methods to measure service quality. To this end, the service quality characteristics are discussed in the next section.

2.2 Service Quality

2.2.1 Traditional Service Quality and Dimensions

In general, the concept of service quality is defined as a form of attitude representing a long run overall evaluation. It is a critical prerequisite and determinant of competitiveness for establishing and sustaining satisfying

relationships with customer. Previous studies suggest that organizations must focus on the satisfaction of customers to gain long lasting competitive advantage.

Various researches have developed alternative concepts for service quality such as the **European perspective** [132-135] and the **American perspective** [4,47]. The European perspective states that service quality should include three dimensions like **technical quality, functional quality and corporate image**. The American perspective proposes that service quality may be evaluated on the **functional quality dimensions** described by five components viz., tangibles, reliability, responsiveness, assurance and empathy [136]. The following definitions provided by different authors give a clear picture of service quality.

Asubonteng et al. defined service quality as “the difference between customers’ expectations for service performance prior to the service encounter and their perceptions of the service received” [137]. According to Gefan, service quality is defined as the subjective comparison that customers make between the quality of the service that they want to receive and what they actually get [138]. In other studies, service quality has been defined as the difference between customer’s expectations of service provider’s performance and their evaluation of the services they received [4,47]. According to Woodside et al., service quality is represented by answers to the questions (i) Is the service delivered to customer what they expected or different from that? (ii) Was the service they received approximately what they expected or better or worse than expected [139]? A majority of studies have sought to find the criteria that contribute to evaluate service quality in the traditional service environment [4,47,132-135,140,141]. The traditional service quality can be defined as the overall evaluation of firm’s service by comparing the firm’s performance with the customer’s general expectations of how firms should perform [4,47].

In order to facilitate measurement of service quality, Parasuraman et al. identified ten determinant such as tangibles, reliability, responsiveness, communication, access, competence, courtesy, credibility, security and understanding/knowledge of customer through group studies [47]. Later these

ten dimensions were further purified and reduced to five dimensions viz., tangibles, reliability, responsiveness, assurance and empathy to measure service quality. They named the measuring instrument as 'SERVQUAL'. Tangibles refer to the physical facilities, equipment and appearance of personnel. Reliability means the ability to perform the promised service dependably and accurately. Responsiveness means willingness to help customers and provide prompt service. Assurance indicates knowledge and courtesy of employees and their ability to inspire trust confidence. Empathy refers to caring and individualized attention that the firm provides to its customers. Gronroos suggested six criteria of perceived service quality viz., professionalism and skills, attributes and behavior, accessibility and flexibility, reliability and trustworthiness, recovery, reputation and credibility [133]. Johnston provides eighteen service quality dimensions: attentiveness/helpfulness, responsiveness, care, availability, reliability, integrity, friendliness, courtesy, communication, competence, functionality, commitment, access, flexibility, aesthetics, cleanliness/tidiness, comfort and security [140]. From the focus group interviews, Berry et al. identified ten determinants of service quality [142]. Virtually all comments consumers made in these interviews about service expectations, priorities and experiences fall into one of these ten categories. These are reliability, responsiveness, competence, access, courtesy, communication, credibility, security, understanding and tangibles. Similarly, Lehtinen and Lehtinen suggest that the service quality has three dimensions, viz., Physical Quality (includes items such as the condition of buildings and enabling equipment), Corporate Quality (refers to the organization's image and profile) and Interactive Quality (derives from the interaction between service organization's personnel and the customer as well as the interaction between customers) [135]. In addition, they argue that it is necessary to differentiate between the quality associated with the process of service delivery and the quality associated with the outcome of the service while examining the determinants of quality.

Service measurement instrument 'SERVQUAL' is claimed as a suitable tool for almost all service sectors. Since the development of 'SERVQUAL', there

has been a growing interest in service quality measurement and its conceptualization in various service sectors such as hospitality, tourism, health care and education. Education needs a special attention because of its inherent characteristic of multi-stakeholder situation and difficulty in resolving the customer or product dilemma for the students. Therefore, quality in education has been described in many ways [143,144]. Some may emphasize the quality of inputs to the education systems whereas others emphasize the quality of processes and outcomes. No matter whether referring to input, process, outcome, or all of these, the definition of education quality may often be associated with fitness for use, the satisfaction of the needs of their stakeholders (e.g. policy makers, parents, teachers and students) and their expectations. Thus, education quality is a multi-dimensional concept and cannot be easily assessed by only one indicator. Furthermore, the expectations of various stakeholders on education may also differ. It is often very difficult for an education institution to meet all the expectations or needs at the same time. Therefore, it is not rare that the education quality in an educational institution is high to the perceptions of some stakeholders but not to the others, or some aspects of an education institution may be of high quality but other aspects may be of low quality [145].

2.2.2 Online Service Quality and Dimensions

Majority of studies view the dimensions of e-service quality (quality of service provided electronically) as the antecedents of traditional service quality dimensions [146,147]. Drawing upon the traditional service quality scale, Zeithaml et al. have developed online quality dimensions for measuring e-service quality [148]. In a series of focus group interviews, they have identified eleven dimensions of online service quality such as access, ease of navigation, efficiency, flexibility, reliability, personalization, security/privacy, responsiveness, trust/assurance, site aesthetics and price knowledge. In their research, they found that the core dimensions of regular service quality like efficiency, fulfillment, reliability and privacy are the same as online service dimensions. At

the same time, they stated that responsiveness, compensation and real time access to help as core dimensions of service recovery for online services. In addition, they noted that empathy was less important for online services unless service problems happen.

In another study, the authors established a scale called 'WEBQUAL' to address the online quality of web-service. It consists of twelve dimensions such as information fit to task, interaction, trust, response time, design, intuitiveness, visual appeal, innovativeness, flow, integrated communication, business process and substitutability [149]. Wolfinbarger and Gilly, through focus group interviews and an online survey, reduced the scale of online service into four key dimensions viz., website design, reliability, privacy/security and customer service [59]. In this study, they suggested that the most basic building of outstanding online service quality is reliability and website design including good functionality in time savings, easy transactions, good selection, in-depth information and the right level of personalization. Wang and Huarng identified nine e-service qualities through content analysis of online customer comments in their research that affect customer satisfaction [150]. These are general feedback on the website design, competitive price of the product, merchandise availability, merchandise condition, on-time delivery, merchandise return policy, customer support, e-mail confirmation on customer order and promotion activities. Madu and Madu proposed the following fifteen dimensions of online service quality [151]. These are performance, features, structure, aesthetics, reliability, storage capacity, serviceability, security and system integrity, trust, responsiveness, service, differentiation and customization, web store policies, reputation, assurance and empathy.

In a series of focus group interviews, empirical data collection and analysis, Zeithaml et al. identified seven dimensions of online service quality viz., efficiency, reliability, fulfillment, privacy, responsiveness, compensation and customer contact [48]. The first four factors are termed as the core dimensions and the later three are termed as secondary factors. They found that responsiveness, compensation and access are the dimensions specific to e-

service quality [62,148]. Wolfinbarger and Gilly reduced the scale of online service quality into four dimensions such as website design, reliability, privacy/security and customer service. They suggested that the most important dimensions associated with the basic online service quality are reliability, website design and customer service [59]. Yang and Jun derived six e-service quality dimensions from an appraisal of service quality literature. They are reliability, accessibility, ease of use, personalization, security and credibility [65]. Yang et al. have uncovered six key online service quality dimensions viz., reliability, access, easy of use, attentiveness, security and credibility. They recommended that reliability, attentiveness, ease of use and access are the critical dimensions to achieve high level of perceived service quality of online customers [60]. Yang and Fang have mentioned that traditional service quality dimensions such as competence, courtesy, cleanliness, comfort and friendliness are not relevant to online service quality whereas other factors like reliability, responsiveness, assurance and access are critical to both traditional and e-service quality [66]. Jun et al. compared traditional with online service quality dimensions and found that four out of five traditional dimensions of SERVQUAL are also considered important in online service quality [67]. Through a questionnaire survey in Singapore, Gerrard and Cunningham have suggested seven factors such as ease of use, service issues, reliability, security, responsiveness, appearance and staff quality [68]. In Malaysia, a survey is conducted to find the key online service quality dimensions such as accessibility, awareness, attitude towards change, cost, trust security and easy of use [69]. Madu and Madu proposed fifteen dimensions of online service quality like performance, features, structure, aesthetics, reliability, storage capacity, serviceability, security, trust, responsiveness, customization, web store policies, reputation, assurance and empathy [151]. Lee and Lin mentioned website design, reliability, responsiveness, trust and personalization as e- service quality dimensions. They suggested that the most significant determinant to overall service quality and customer satisfaction is the ‘trust’ rather than ‘reliability’ and the least important dimension is the website design [152]. It has been observed that five dimensions

are commonly used in online service quality. They are ease of use, website design, customization, responsiveness and assurance [146]. Based on the previous literature and interview of focus groups Santos developed a conceptual model of e-service quality [153]. This model consists of two groups of dimensions - incubative and active. According to him before launching of a website, the incubative dimensions need to be considered. After a website has been established, the active dimensions need to be maintained throughout the entire period of active e- commerce on the website. The determinants of active dimensions are reliability, efficiency, support, communication, security and incentives. Trocchia and Janda, using responses from interviews, identify five e-service quality factors such as performance, access, security, sensation and information [58].

But, the arrival of widespread use of Internet in the service sector poses a challenge to service quality researchers. The traditional service quality models require several modifications in order to accommodate the online service settings. To this end, various models of e-service quality have been proposed by researchers to enrich the literature [62-69,148]. The service quality has been widely used to assess the performance of various service organizations including banks. To our knowledge, comparatively less literature is encountered in the area of service quality dimensions specific to Internet baking. Joseph et al. investigated the influence of Internet on the delivery of banking service [48]. They found six underlying dimensions of e-banking service quality such as convenience and accuracy, feedback and complaint management, efficiency, queue management, accessibility and customization. Jun and Cai identified seventeen service quality dimensions of Internet banking service quality. These are reliability, responsiveness, competence, courtesy, credibility, access, communication, understanding the customer, collaboration, continuous improvement, content, accuracy, ease of use, timeliness, aesthetics, security and divers features. They also suggested that some dimensions like responsiveness, reliability and access are critical for both traditional and Internet banks [52]. A qualitative research approach in UK reveals that the dimensions important to the

online banking customers are reliability, efficiency, responsiveness, assurance, ease of use and information [53]. Jayawardhena transforms the original SERVQUAL scale in the Internet context and develops a battery of twenty-one items to assess service quality in e-banking. By means of an exploratory (EFA) and confirmatory factor analysis (CFA), these twenty-one items are condensed to five quality dimensions such as access, website interface, trust, attention and credibility [54]. Internet banking is one of the growing service sectors that need to provide better service through improvement on online service quality via measurement of relevant service dimensions.

Any organization whether provides traditional or online service must develop a comprehensive service quality approach to be used organization-wide so that customer satisfaction can be improved. The dimensions and measurement scale of the service quality is simply used to evaluate customer satisfaction for the quality approach used by the firm. Therefore, it is prudent to discuss on various models of service quality suggested by different authors in the literature [154]. Some of the important models of service quality are presented below.

2.3 Service Quality Approaches

2.3.1 Technical and Functional Quality Model

To compete successfully, a firm must have an understanding of consumer perception of the quality and the way service quality is influenced. Managing perceived service quality means that the firm has to match the expected service and perceived service to each other so that consumer satisfaction is achieved.

It has been identified that three components of service quality viz., technical quality, functional quality, and corporate image as shown in Figure 2.4 are adequate to define service quality [139]. The arrows in the diagram indicate the interaction of different components of the service quality model.

1. Technical quality is the quality of what consumer actually receives as a result of his/her interaction with the service firm and is important to him/her and to his/her evaluation of the quality of service.

2. Functional quality is how he/she gets the technical outcome. This is important to him and to his/her views of service he/she has received.
3. Image is very important to service firms and this can be expected to build up mainly by technical and functional quality of service including the other factors (tradition, ideology, word of mouth, pricing and public relations).

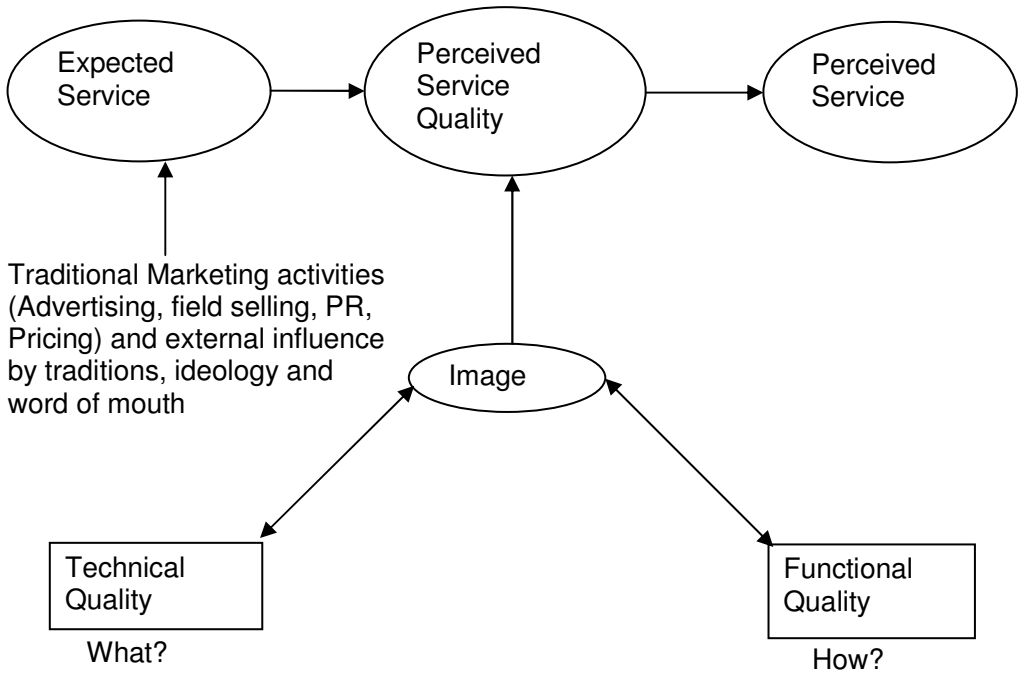


Figure 2.1: Technical and Functional Quality Model

2.3.2 Gap Model

Parasuraman et al. proposed that service quality is a function of the differences between expectation and performance along the quality dimensions [45]. They developed a service quality model based on gap analysis (Figure 2.5). The arrows in the diagram indicate direction of influence of a component of the model on another component. The various gaps visualized in the model are:

- **Gap1**: Difference between consumers' expectation and management's perceptions of those expectations, i.e. not knowing what consumers expect.

- **Gap2**: Difference between management's perceptions of consumer's expectations and service quality specifications, i.e. improper service-quality standards.
- **Gap3**: Difference between service quality specifications and service actually delivered i.e. the service performance gap.
- **Gap4**: Difference between service delivery and the communications to consumers about service delivery, i.e. whether promises match delivery?
- **Gap5**: Difference between consumer's expectation and perceived service. This gap depends on size and direction of the four gaps associated with the delivery of service quality on the marketer's side.

The service quality is a function of perception and expectations and can be modeled as [154].

$$SQ = \sum_{j=1}^{k} \left(P_{ij} - E_{ij} \right) \tag{2.2}$$

Where:

SQ = overall service quality; k = number of attributes.

P_{ij} = Performance perception of stimulus i with respect to attribute j.

E_{ij} = Service quality expectation for attribute j that is the relevant norm for stimulus i.

This exploratory research was refined with their subsequent scale named 'SERVQUAL' for measuring customers' perceptions of service quality [40]. At this point, the original ten dimensions of service quality collapsed into five dimensions such as reliability, responsiveness, tangibles, assurance (communication, competence, credibility, courtesy, and security) and empathy that capture access and understanding/knowing the customers. Later, 'SERVQUAL' was revised in 1991 and 1994 by reducing the total number of items to twenty-one, but five dimensional structure remains as such.

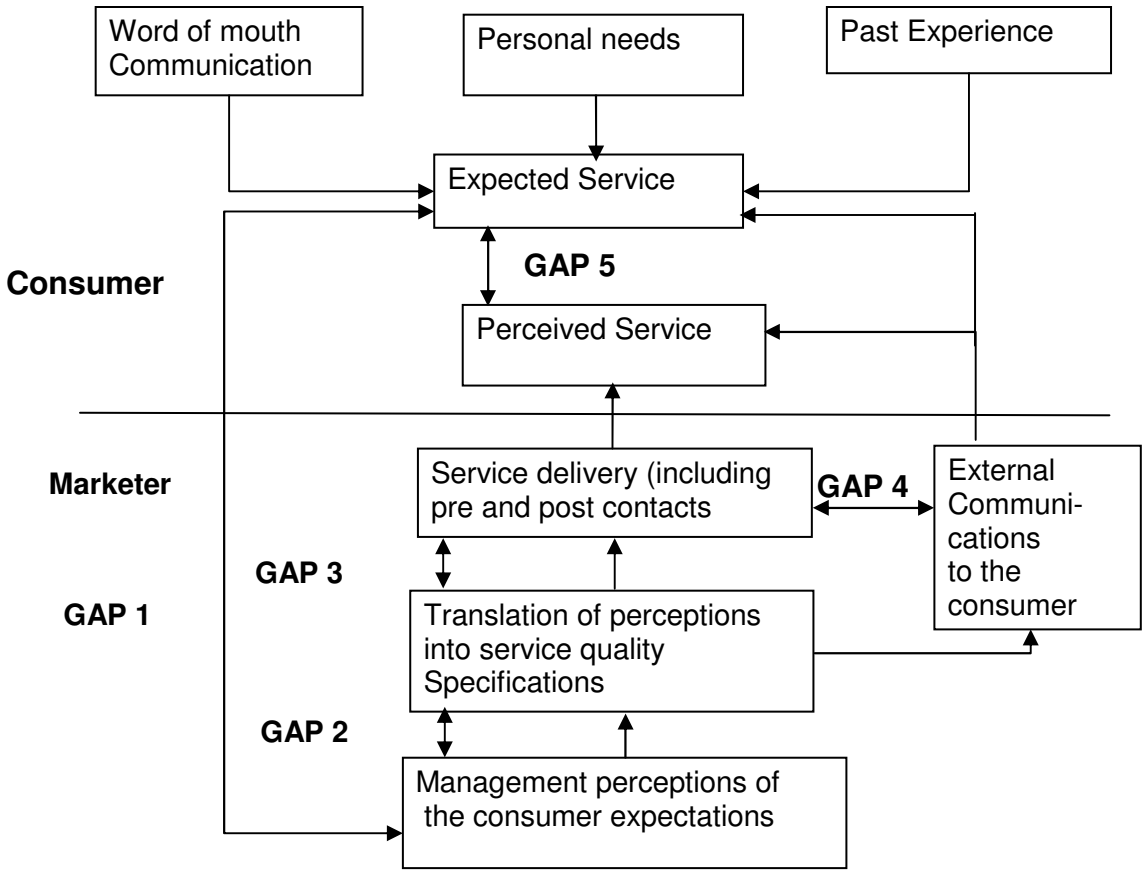


Figure 2.2: GAP Model

2.3.3 Performance only Model

Cronin and Taylor investigated the conceptualization and measurement of service quality and its relationship with consumer satisfaction and purchase intentions [5]. They compared computed difference scores with perception to conclude that perceptions only are better predictor of service quality. They argued on the framework of Parasuraman et al. with respect to conceptualization and measurement of service quality. This leads to develop performance only measurement of service quality called 'SERVPERF'. They illustrated that service quality is a form of consumer attitude and the performance only measure of service quality is an enhanced means of measuring service quality [5,47]. The argument says that 'SERVQUAL' confounds satisfaction and attitude. Service quality can be conceptualized as "similar to an attitude" and can be

operationalized by the adequacy-importance model. In particular, they argued that 'Performance' instead of "Performance-Expectation" determines service quality.

Service quality is evaluated by perceptions-only without expectations and importance weights as follows:

$$SQ = \sum_{j=1}^{k} P_{ij} \tag{2.3}$$

Where:

SQ = overall service quality;

k = the number of attributes;

P_{ij} = performance perception of stimulus i with respect to attribute j.

2.3.4 Evaluated Performance and Normed Quality Model

According to Teas, the conventional disconfirmation model has conceptual, theoretical and measurement problems [155]. He pointed out some of the issues in the measurement of service quality using 'SERVQUAL' are conceptual definition ambiguity, theoretical justification of expectations in the measurement of service quality, the usefulness of the probability specification in the evaluated performance (EP) measurement and link between service quality and consumer satisfaction/dissatisfaction. The author proposed two frameworks for service quality.

***Evaluated performance (EP) framework**:* In this framework perceived quality is modeled as:

$$Q_i = -1\left[\sum_{j=1}^{m} w_j \left|\left(A_{jk} - I_j\right)\right|\right] \tag{2.4}$$

Where:

Q_i = The individual's perceived quality of object i.

w_j = Importance of attribute j as a determinant of perceived quality.

A_{ij} = Individual's perceived amount of attribute j possessed by object i.

I_j = The ideal amount of attribute *j* as conceptualized in classical ideal point attitudinal models.

m = Number of attributes.

With an assumption that perceived ability of the product to deliver satisfaction can be conceptualized as the product's relative congruence with the consumer's ideal product features.

Normed quality model: If the object *i* is defined as the excellence norm that is the focus of revised 'SERVQUAL' concept, the above equations can be used to define the perceived quality of excellence norm Q_e in terms of the similarity between the excellence norm and the ideal object with respect to "*m*" attributes. The quality of another object *i*, Q_i relative to the quality of excellence norm then normed quality (*NQ*) is modeled as:

$$NQ = [Q_i - Q_j] \tag{2.5}$$

Where

NQ = Normed quality index for object *i*.

Q_e = The individual's perceived quality of the excellence norm object.

For infinite ideal points, normed quality is:

$$NQ = \sum_{j=1}^{m} w_j (A_{ij} - A_{ej}) \tag{2.6}$$

Where

A_{ej} = individual's perceived amount of attribute "*j*" possessed by the excellence norm "*e*".

2.3.5 P-C-P Attribute Model

In this model, the authors propose a hierarchical structure based on three main classes of attributes such as pivotal, core and peripheral as shown in Figure 2.6 [156]. According to this model, every service consists of three overlapping areas where the vast majority of the dimensions and concepts been

used to define service quality. These ranked levels are defined as pivotal (outputs), core and peripheral (jointly representing inputs and processes).

The pivotal attributes can be considered as the determining attributes or the output of a service encounter. It has the greatest influence on the satisfaction levels of customer. After the service process is completed the information regarding the service delivery in respect of the expectations and perceptions of consumers are collected through these attributes. The core attributes can be described as the combination of people, processes and the service organizational structure. The peripheral attributes can be defined as the attributes that add further to delight the customers. When a consumer makes an evaluation of any service encounter, he is satisfied if the pivotal attributes are achieved but as the service is used more frequently the core and peripheral attributes may begin to gain importance.

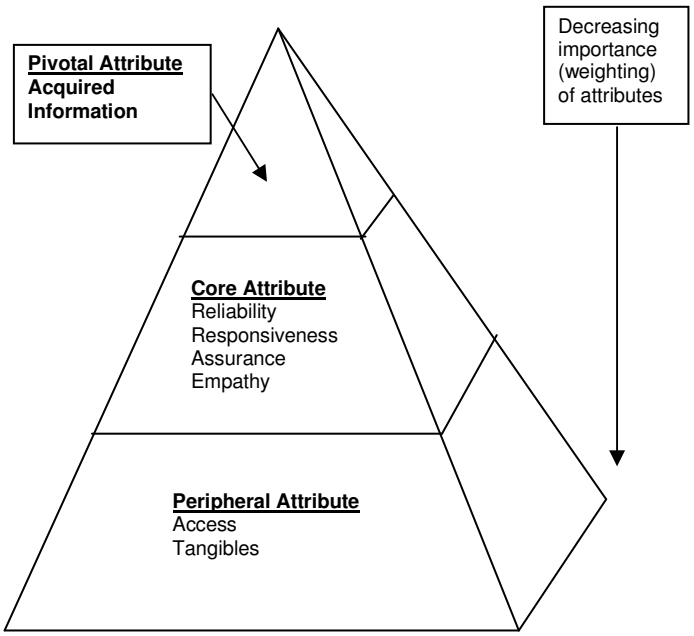


Figure 2.3: P-C-P Attribute Model

2.3.6 Internal Service Quality DEA Model

Soteriou and Stavrinides suggested a service quality model that can be used to provide guidelines in service sector such as a bank branch for optimal

utilization of its resources [157]. The model can also be extended to other service sectors. The model does not aim at developing the service quality measures rather guides how such measures can be incorporated for service quality improvements. The model points out resources that are not properly utilized. The inputs to the model consist of two sets: (i) consumable resources such as personnel, space and time and (ii) the number of accounts in different categories. The output of the model is the level of service quality perceived by the personnel of the branch. The data envelope analysis (DEA) model (Figure 2.7) compares branches or Decision Making Units (DMUs) on how well they transform these resources (inputs) to achieve their level of service quality (output) given the client base. The DEA model will identify under-performers (inefficient units) and suggest ways for their improvement. Generally two models of DEA are used to calculate the relative efficiency of the service units. The input minimization DEA model will provide information on how much could the consumables resources be reduced while delivering the same level of service quality, while the output maximization DEA model will provide information on how much service quality can be improved using the same consumable resources.

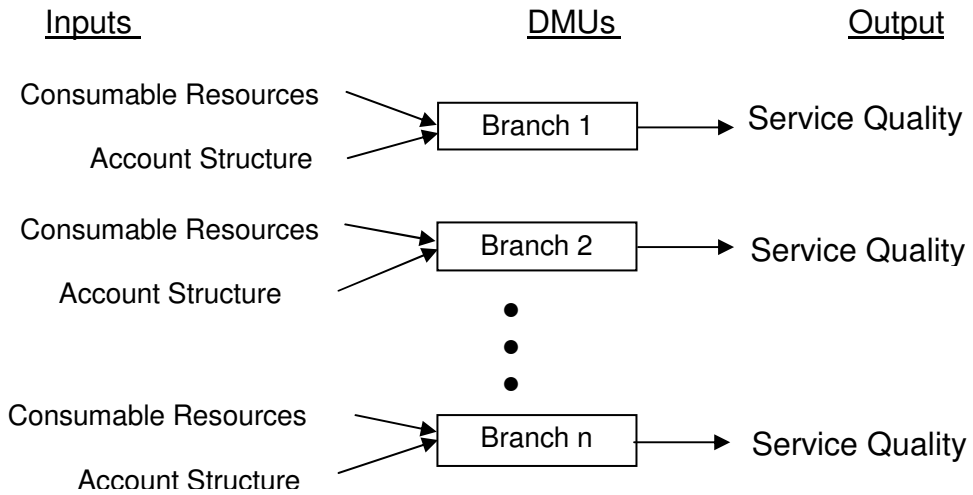


Figure 2.4: Data Envelop Analysis Service Quality Model

2.3.7 Internet Banking Model

One of the key challenges of the Internet as a service delivery channel is how service firms can manage service quality as these remote formats bring

significant change in customer interaction and behavior [56]. This study proposes and tests a service quality model of Internet banking (Figure 2.8). The arrows in the diagram indicate interaction of different elements of the model. The research uses participant observation and narrative analysis of UK Internet web site community to explore how Internet banking customers perceive the elements of this model. In the context of internet, five key elements are treated as central influences on perceived service quality: They include customer expectations of the service, the image and reputation of the service organization, aspects of the service setting, the actual service encounter and customer participation.

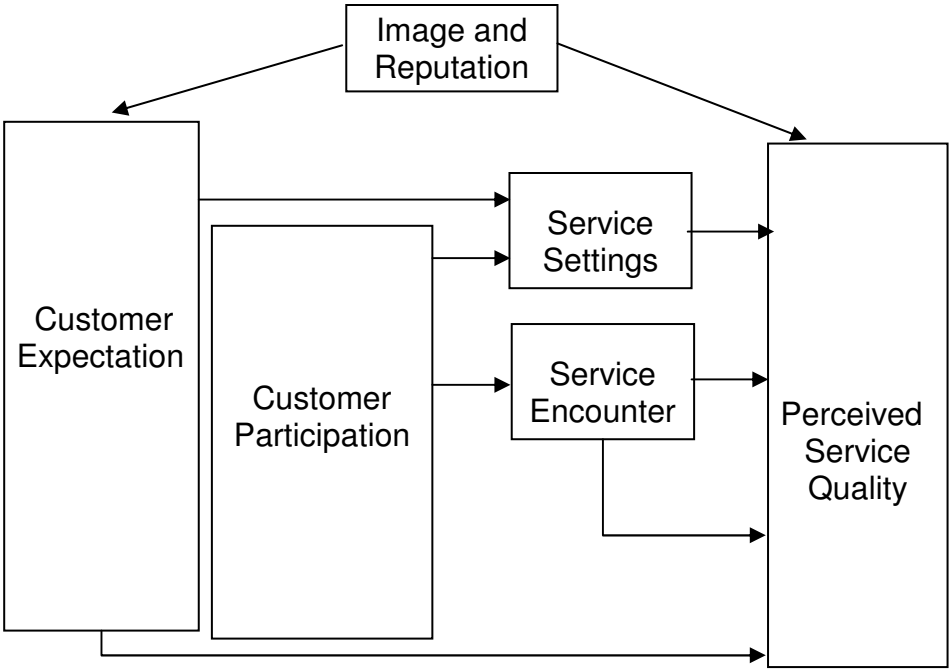


Figure 2.5: Internet Banking Service Quality Model

2.3.8 Model of E-Service Quality

Service quality is one of the key factors in determining the success or failure of electronic commerce and e-service can be defined as the role of service in cyberspace, in other words, 'electronic service provided to the customer, [158]. Santos proposes a conceptual model of e-service quality (Figure 2.9) with its determinants [153]. It is proposed that e-service quality have incubative (proper

design of a web site, how technology is used to provide consumers with easy access, understanding and attractions of a web site) and active dimensions (good support, fast speed, and attentive maintenance that a web site can provide to its customers) for increasing hit rates, stickiness, and customer retention.

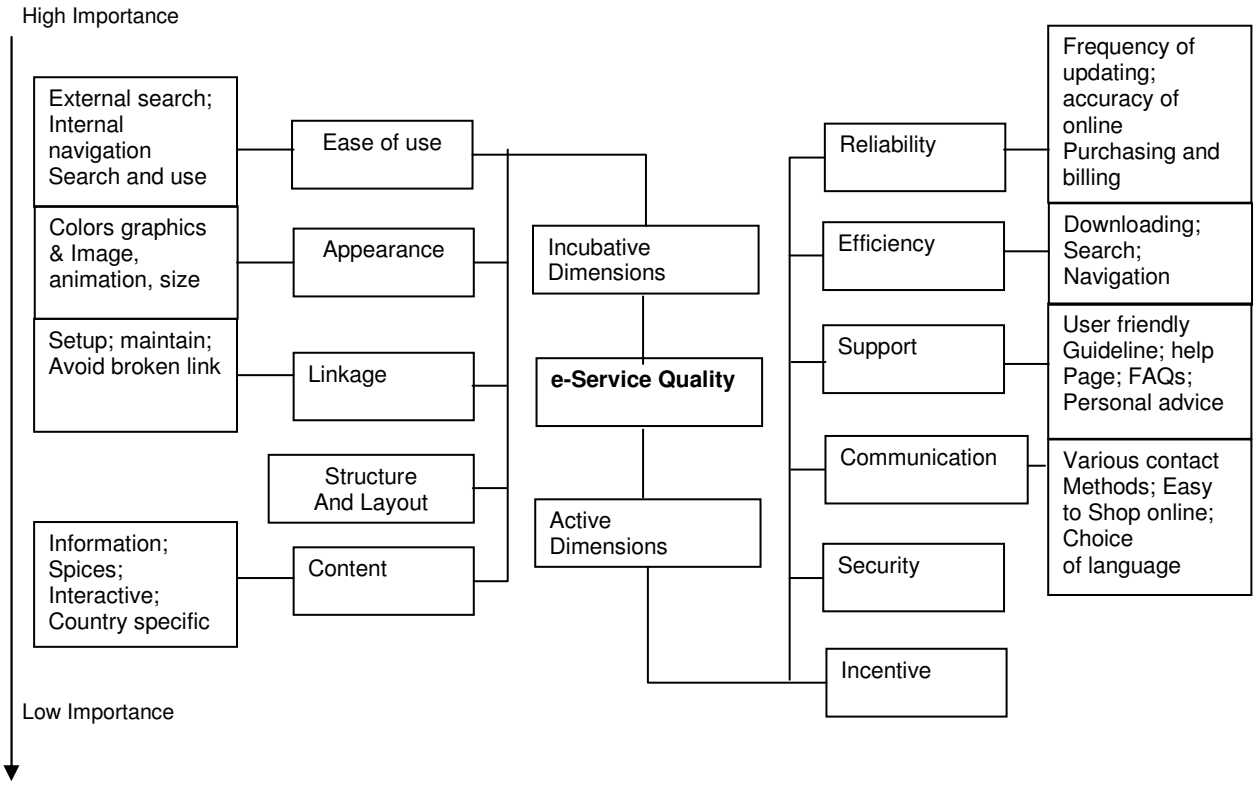


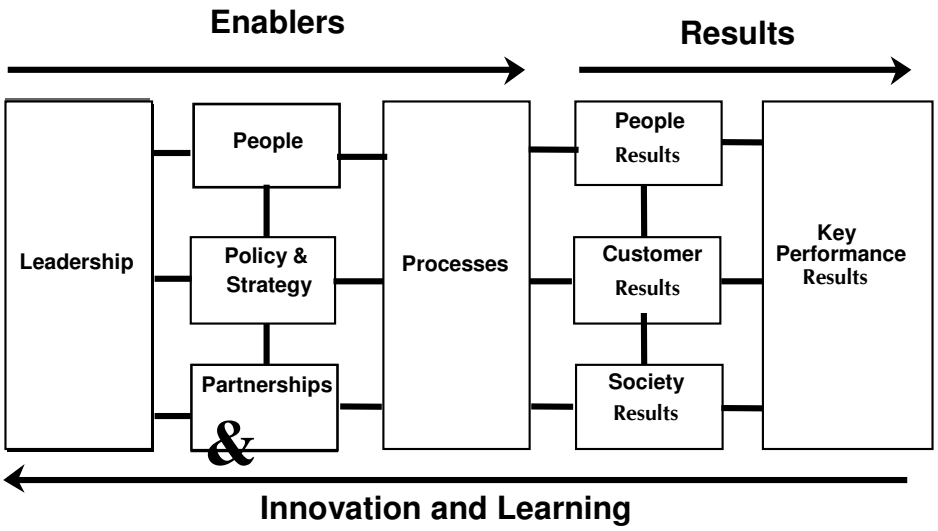
Figure 2.6: E-Service Quality Model

2.3.9 The EFQM Excellence Model: An Integrated Approach for TQM

The EFQM (European Foundation for Quality Management) Excellence Model was introduced at the beginning of 1992 as the framework for assessing organizations for the European Quality Award. It is now the most widely used organizational framework in Europe and it has become the basis for the majority of national and regional Quality Awards. It is a practical tool that can be used in a number of different ways such as **Self-Assessment, Benchmarking, Process Improvement** and **Structure** for the organization's management system.

The EFQM Model provides a generic framework of criteria, which can be equally applied to any organization regardless of size, sector and structure.

Developed as a reference framework for the European Quality Award, the basic principle of the EFQM Model is that customer and staff satisfaction and integration into society are achieved via the role of the organizational leadership in setting the policy and strategy and the management of staff, resources and processes culminating in excellence in key performance results (Figure 2.10).



2.4 Critical Appraisal of the Existing Approaches

Quality is defined in many ways by various proponents making it a complex topic to understand. Crosby describes quality as an elusive and indistinct construct often mistaken for imprecise adjectives like goodness, luxury, shininess or weight [26]. The explanation and measurement of quality also poses problems for researchers who often bypass definitions and use uni-dimensional self-report measures to capture the concept [159-162]. Although, the concept of quality is still to be understood, its significance in increasing the productivity of the firm and satisfying the customers has already been illustrated [163,164]. The foundation for understanding the concept of quality and quality management principles derives from the work carried out by various proponents of quality viz. Crosby [26], Deming [27], Juran [165], Feigenbaum [166] and Taguchi [167]. Critical review of philosophies proposed by five important proponents of quality

leads to conclude that each has his own distinctive approach although they do share some common points as summarized below:

1. It is management's responsibility to provide commitment, leadership, empowerment, encouragement, and the appropriate support to technical and human processes. Top management must determine the environment and framework of operations within a firm. It is imperative that management fosters the participation of the employees in quality improvement and develops a quality culture by changing perception and attitudes toward quality.
2. The strategy, policy, and firm-wide evaluation activities are emphasized.
3. The importance of employee education and training is emphasized so that changes in employees' beliefs, behavior, attitudes and their abilities can be effected.
4. Employees should be recognized and rewarded for their quality improvement efforts.
5. Effective product design, process control, and quality improvement projects must be emphasized in a rigorous manner. The focus should be on prevention of product defects; not inspection after the event.
6. Quality is a systematic firm-wide activity from suppliers to customers. All functional activities such as marketing, design, engineering, purchasing, manufacturing, inspection, shipping, accounting, installation and service should be involved in quality improvement efforts.

Three major Quality Awards Models viz. Deming Prize in Japan (1996), the European Quality Award in Europe (1994), and the Malcolm Baldrige National Quality Award in the United States of America (1999) are quite popular among industries throughout the world for pursuing improvement on quality. The award models facilitate to create a superior environment for quality improvement focusing on objectives viz., (1) increasing awareness of TQM (2) sharing of information (3) systematic self-assessment (4) understanding of requirements and (5) encouragement for continuous improvement process. These quality

award models provide a universal framework for evaluating various aspects of TQM practices in a firm. They also provide a framework for identifying a range of intangible and tangible processes that influence the firm's TQM implementation and the end results. Although each award has its own unique categories and emphasis, there are some common areas:

1. Each award model has two parts: One is TQM implementation (that is, the enablers); the other is the overall business result. TQM implementation makes overall business results happen.
2. All three award models emphasize the importance of leadership, human resources management, employee participation, employee education and training, process management, strategy and policy, information, supplier quality management, and customer focus.

Regarding the various service quality models discussed in section 2.3.1 to 2.3.9 the gap model considers the perceptions and expectations of the customers, the gap being the difference between expectations and perceptions (P-E). The model resulted in five dimensions that are generic in nature. However, other models such as 'Technical and Functional Quality Model', 'Perception-only Model' and 'Evaluated Performance and Normed Quality Model' consider only the perceptions of the customers. Technical and Functional Quality Model describes three components such as technical quality (the quality received by the customer), functional quality (how the quality is received by the customer) and corporate quality (how quality is delivered by the organization). In the Perception-only Model, all the dimensions of gap model are considered using the perceptions of the customers only. In the Evaluated Performance and Normed Quality Model, the performance measurement has been conducted from the customer's satisfaction/dissatisfaction only. In P-C-P Model, the dimensions of the gap model are compressed into three attributes such as Pivotal, Core and Peripheral attributes. These attributes contain all dimensions mentioned in the gap model. This model also considers the expectations and perceptions of the customers.

In DEA model, the service quality is determined in an indirect way by finding the efficiencies of the DMUs, the inefficient units located from this can be improved so that the organization can provide quality service to its customers. Basically, Internet Banking Model and E-Service Quality Model determine the service quality through the customer expectations and perceptions, customer participation, image, reputation and service setting of the organizations. In addition to the traditional dimensions, some dimensions relevant to e-services and Internet banking such as security, privacy, ease of use, linkage in website and appearance are common in these models. The EFQM Excellence Model helps for benchmarking and improvement of overall performance of organizations focusing on key factors of TQM and assures quality service to its customers in turn.

2.5 A Critique on Service Quality Measurement and Evaluation

SERVQUAL is a widely used instrument to measure customer evaluations of service quality [48]. Despite a leading instrument in measuring service quality, a number of studies have raised concern about it [156,168-171]. These criticisms relates to conceptual, methodological and analytical issues in SERVQUAL.

The primary issue raised in the literature is the conceptualization of service quality as the difference between perception and expectation [159]. Cronin and Taylor, reiterate their views against the disconfirmation based SERVQUAL scale of measuring service quality and continued to be proponents of their perception-only approach to service quality measurement. Further, the use of the perception and expectation gap measure of service also raises related analytical concerns about its low reliability, poor discriminant validity and spurious correlations [168-170]. Parasuraman et al. indicate that on the issue of discriminant validity, SERVQUAL performs just as well as the perception-only model SERVPERF on various validity criteria [56, 57]. They also highlighted the fact that the inter-factor correlations in SERVQUAL have always been recognized as being present [4, 55]. In fact, they identify that the nature and causes of these interrelationship between factors representing the service quality dimensions are

a useful area for further research. The diagnostic value of different approaches to measure service quality is also in dispute. Parasuraman et al. show that service quality measurement that include customer expectations provide more information to managers than those that focus on perceptions only [56, 57]. However, Cronin and Taylor argue otherwise by stating the popularity of the perception-only approach [172].

Ultimately, from the above discussions, it must be recognized that the purpose of measurement is to improve service quality. Managers should be able to understand where limited resources must be applied in order to achieve the greatest improvement for their customers. As such, measurement of gaps and perception-only should be evaluated for their ability to provide assistance to managers in this regard.

Numerous tools exist for evaluation of service quality. Particularly, Artificial Neural Network (ANN) and DEA need special attention because of their generality capability, easiness to adopt in any situation, and robustness. ANN is a soft computing tool that can be used to model human decision-making process as it has the capability to predict an output, classify a given set of inputs into different groups (known as the pattern recognition), and incorporate heuristic criteria [87]. As neural network can effectively exploit and represent the non-linear relationship between the consumer satisfaction and their perception of the service, it can be used for modeling of a customer's decision making [21]. Similarly, Data Envelopment Analysis (DEA) is a technique that aggregates the input and output components in order to obtain an overall performance measure through the comparison of a group of Decision Making Units (DMUs). It evaluates performance of DMUs by finding out the relative efficiency of the units under consideration. The major advantages of DEA being utilization of multiple inputs and multiple outputs with out any functional relationship between them and independence of units of measurement of various parameters. It also determines the possible sources of inefficiency and identifies the benchmarked DMUs.

2.6 Evaluation of Service Quality using Neural Networks

Evaluation of service quality by implementing a neural network approach has been discussed by various researchers. A number of successful business applications of neural networks have been discussed in the literature, particularly in financial services [24], transportation services [23] and telecommunications [76]. Lu et al. compared the effectiveness of neural networks and the multinomial logit model, and concluded that the ANNs perform better than logit regressions in franchising decision-making [77]. Wu et al. applied neural network approach for the decision surface modeling of apparel retail operations [78]. Tam and Kiang discussed a BP neural network application in predicting future bank bankruptcy based on financial ratios [24]. Dutta and Shekhar applied neural networks to a generalization problem of predicting the corporate bond ratings [79]. Chiang et al. discussed a BP neural network approach to mutual fund net asset value forecasting [80]. Hu et al. found that the ANN performed better than logistic regression in the modeling of foreign equities [81]. Kimoto et al. applied modular neural networks to develop a buying and selling timing prediction system for stocks on the Tokyo Stock Exchange [82]. They developed a high-speed learning method called supplementary learning that is actually based on error back propagation. Odom and Sharda developed a neural network model using back propagation for prediction of bankruptcy [83]. They claimed that their model performed better than discriminant analysis which is generally used for this class of problems. A study by Kattan demonstrated that the BP neural network is suitable to predict the self-reported usage of a popular graphics software package [84].

In education sector, few neural network models have been developed to predict the academic performance of educational institutions considering qualitative and quantitative criteria [22,85-87]. However, the application of neural networks to model qualitative and intangible aspects of different services is not addressed adequately in the literature. It may be appropriate to extend implementation of neural networks to address more general and theoretical

issues in service sector, such as education, particularly modeling students' evaluation of service quality of an institution.

2.7 Measurement of Efficiency, Performance and Service Quality using DEA

DEA finds many applications in literature in order to evaluate the performance and the quality of the organizations. In a study DEA has been used in a retail electronic energy services as a diagnostic tool for effective management of service quality [173]. Soteriou and Stavrinides developed a DEA model that suggests a direction for improvement to bank branches which do not use their resources in the most efficient way to produce service quality [157]. In another study the authors demonstrated the results on evaluating the efficiency-effectiveness relationship of quality circles (QCs) and gain insights into the ways to improve performance of QCs which in turn could be used by a manager to take the necessary corrective actions [174]. Marshall and Shortle used DEA and VEA (Value Efficiency Analysis) explores the inefficient countries in mid-Atlantic countries in their quality of life production [175]. Recently, several studies have been undertaken for analysis of efficiency in education sector using Data Envelopment Analysis (DEA) methodology. Each study differs in its scope, meaning, and definition of DMUs. Rodhes and Southwick used DEA to compare the efficiency of some private universities with the public in USA [176]. Tomkins and Green conducted the DEA analysis to test the performance of twenty accounting departments in UK [109]. Johnes and Johnes investigated the use of Data Envelopment analysis in the assessment of performance of university departments of the UK over the period 1984-1988 [110]. McMullen has applied DEA to assess the relative desirability of AACSB (Association to Advanced Collegiate Schools of Business) accredited MBA programs [111]. In this study, the authors have incorporated several attributes of MBA programs into model for finding out most desirable program in terms of these attributes. Mcmillan and Datta have assessed the relative efficiency of 45 Canadian universities using DEA [112]. Subsets of universities including universities from each of three categories such as comprehensive with medical school, comprehensive without

medical school, and primarily undergraduate are regularly found efficient with some universities showing inefficiency. But, overall efficiency for most of the universities is relatively high. Ramanathan has compared the performance of selected schools in the Netherlands using DEA and found that the efficiencies of the schools are in line with their performance [113]. The author also observed the effect of several non-discretionary input variables which can influence the efficiency scores but which are not in direct control of management of the school. Lopes and Lanzer address the issue of performance evaluation, productivity and quality of academic departments at a University using a DEA model for cross-evaluation between departments considering the dimensions of teaching, research and service quality [114]. The author observed zero correlation between department teaching, research and service and weak correlation between research productivity and quality. Joseph Calhoun employs two methods of DEA to compare relative efficiencies of institutions of higher learning (IHLs) [177]. In addition to comparing private and public IHLs, the paper introduces a new way to group institutions. IHLs are separated by the percent of unrestricted revenue. Those with unrestricted revenue above a certain threshold are grouped together and those with unrestricted revenue below that threshold are grouped together regardless of their private or public affiliation. Martin conducted an application of DEA methodology in the assessment of the performance of Zaragoza Universities departments in Spain [116]. The results included concerns both about teaching and research activities of the departments. The paper also discuss about the existence of difference in the strengths and weaknesses between departments of different area. Jill Johnes applied DEA to 2568 graduates from UK universities in 1993 in order to assess teaching efficiency [117]. Each individual's efficiency is decomposed into two components - one attributable to the university at which the student studied and the other attributable to the student himself. From the former component, a measure of each institution's teaching efficiency is derived and compared to efficiency scores derived from a conventional DEA applied to each institution as a decision making unit (DMU). The results suggest that efficiencies derived from DEA performed at

an aggregate level include both institution and individual components and are therefore misleading indicating the importance of unit analysis in DEA. Ray and Yongil in their study employed a measure of Pareto-Koopmans global efficiency to evaluate the efficiency levels of MBA programs in Business Week's top-rated list [118]. They computed input and output oriented radial and non-radial efficiency measures for comparison. Among three tier groups, the schools from a higher tier group on an average are more efficient than those from lower tiers although variations in efficiency levels do occur within the same tier. Deokro Lee has studied the organizational effectiveness in research centers and institutes (CIs) within public higher education institutions [119]. In particular, this study focuses on how to measure their effectiveness by integrating competing conceptions of effectiveness. This study uses DEA to examine the relative performance or organizational effectiveness of CIs based on the Competing Values Framework (CVF) as a theoretical foundation. The CVF encompasses four representative organizational effectiveness models such as rational goal model, open system model, human relations model, and internal process model. By employing DEA methodology, this study identified the "best practice" exhibited by organizations on the efficient frontier and makes recommendations regarding how "sub-best practice" CIs could become more efficient and performs according to "best practice" standards in each model of the CVF. In India comparatively less number of studies has been conducted in DEA. In a study, an integration of DEA and KM (Knowledge Management) methods are used to evaluate the efficiency of technical education system in India [18]. The authors claim that the suggested approach can assist decision makers in selecting proper institutes to further strengthen the technical education system in an efficient and effective manner.

2.8 Conclusions

In this section, the concept of 'quality' has been addressed from the point of view of the various quality gurus and different quality awards such as Deming Prize, European Quality Model and Malcolm Baldrige National Quality Award. A thorough analysis of literatures has been carried out to assess the current research activities and the future trend of TQM implementation. The investigation clearly indicates that relatively less number of articles cover application of TQM practice in some way or other to improve the quality of service that have bearing on successful TQM implementation. The low percentage of TQM adoption in service sector may be attributed to intangible components associated with it. The trend of current literature suggests that potential exists for research in the area of service quality management, particularly measurement and evaluation of service quality. Since service quality is a composition of intangibility and behavioral aspects, it is not only difficult to assess but also the measuring instruments vary widely across industry type. Therefore, the general overview of traditional service quality and e-service quality has been discussed to have insight of the subject. It is concluded that various authors suggested different dimensions for measuring service quality both in traditional as well as in the online service settings. However, the most widely used instrument for measuring traditional service quality is 'SERVQUAL' and for evaluation of online service quality, the e-service quality model of Zeithaml et al. are frequently used in the literature [4,148]. Finally, various service quality models from the literature have been presented in the last sections. It is found that some of the quality dimensions like ease of navigation, flexibility, personalization and security/privacy are specific to e-service quality whereas few dimensions like reliability, responsiveness, accessibility are common in both traditional and online services. One of the important dimensions of traditional service quality i.e. "empathy" is least emphasized dimension in e-service quality. Finally, various service quality models have been discussed to understand finer underpinnings of service quality. The relative advantages and basis of each model has been discussed. It has been found that 'Gap model' is largely popular

among the researchers because of easiness in expressing service quality in terms of expectations and perceptions by the customers.

CHAPTER III

Design of Instrument for Service Quality Measurement

3.1 Introduction

'SERVQUAL' is the most extensively used service quality measurement instrument because of easiness to use, possession of simple structure and capability of generalization. Since quality of service largely depends on the human behavior, the quality dimensions of a measuring instrument vary with service settings. For example, 'empathy' and 'responsiveness' are significant in health-care sector whereas 'reliability' is important in transportation. Similarly, the components of quality in a fast food restaurant are very different from those on a railway or a bank or a holiday resort. Therefore, quality of service is much difficult to define precisely because service provider generally provides utility, not objects as in case of manufacturing sector. The diverse components of service sector make its quality control and improvement more difficult to generalize. Sometimes number of dimensions or items under each dimension is modified to suit a particular application [171,178]. In education sector, persistence of intangibility and lack of physical evidence of service makes perceptions of service quality a complex composition and its analysis becomes difficult. Specifically, Technical Education System (TES) is characterised as multiple stakeholders with different backgrounds and varied behavioral patterns. In order to evaluate the quality at aggregate level fitting to most of the important stakeholders, a new instrument known as 'EduQUAL' is proposed using 'SERVQUAL' as foundation. A detailed discussion on data collection, testing of robustness of the instrument and analysis is provided subsequently. Normally, two approaches such as quantitative and qualitative are adopted for conducting a scientific research [179]. Quantitative approach is one in which the investigator primarily emphasizes the observable facts developing knowledge (i.e. cause and effect thinking, reduction to specific variables, hypotheses and questions, use of instrument and observation and the test of theories) by employing strategies of inquiry such as experiments and surveys and collects data on predetermined instrument that yield statistical data [180]. In qualitative approach the inquirer gains knowledge through constructivist or advocacy/participatory perspectives or both [180]. Quantitative approach is the convenient way of gathering information on subjects

and its analysis. This study uses quantitative approach for expressing behavioral pattern of various customers of education sector for measuring service quality. In the next section a detail study of the stakeholders of a TES with their objectives are presented.

3.2 Stakeholders in Technical Education System

Quality improvement of any service organization depends on the identification of its customers and to meet their requirements. In education, quality is all about systems that lead to good academic culture, excellent academic results, progressive and adaptive management, clean administration, and prominent profile of outgoing students. It involves the expectations and perceptions of a large number of interested parties such as students, faculty, supporting staff, college administrations, parents of the students, alumni, domestic and offshore partners, career advisor, government, industry (recruiters) and society [181]. Various customers interact with the system in different ways and their objectives may be different. An institution must cater to the needs of their customers keeping in view of their requirements. Before implementing any quality improvement program, it is highly essential to identify various potential customers in an educational set up and determine their specific needs to maintain customer-oriented service [182,183].

It is a subject of debate regarding the ambiguity in defining who the customers of education system are. Many authors classify the customers of the system in different ways. Dawney et al. consider students as the primary customer in an education system, because they are internal as well as external customers [184]. While being in the system, a student is an internal customer participating in the learning process. He becomes an external customer when he leaves the system (alumni). Then, he becomes the ultimate external customer functioning effectively in the society. All other customers are grouped as the secondary customers. In another study, the customers of the higher education system are classified into primary and secondary groups on the basis of their locations (internal or external) and the frequency of interactions by them with the

institution [185]. Sirvanci indicates that the students are generally assumed as the principal customers of the institutions [186]. They are the product in the process, the internal customers for many campus facilities, the laborers of the learning process and the internal customer for delivery of the course material. Sometimes customers in an education setting are grouped as input customers, transformation customers and output customers. Students and parents are included as input customers, the faculty is the transformation customer and the corporations and the society are the output customers [187]. Thus, it is evident that the students are generally accepted as primary customers and the other potential customers such as alumni, parents, employers, employees, government, industry and society may be considered as secondary customers [109].

Imparting quality education necessitates examining the behavioral patterns of various stakeholders in an institute with regard to their expectations and perceptions. To this end, attempt has been made to classify different stakeholders of the technical education system according to their objectives and interactions with the system (Figure 3.1). The Figure consists of four layers of components viz., the system, the stakeholders, the relationships between them and the objectives of the different stakeholders. The students are the users of a TES. They use the facilities provided by the TES to become competent technical professionals whereas the responsibility of stakeholders such as academic staff, administrative staff and the management is to impart quality service to the students. Similarly, the stakeholders who take interest in the TES for supporting its improvement through technology exchange and career development are alumni, parents of the students, career advisors, domestic and foreign partners. The industries and the government require the products of a good TES such as technology solution, skilled work force, products, process for the development of industry and economic growth. Lastly, the impact of TES on society is to develop the socio-economic condition of the country.

Among all the stakeholders, the students of an institute may be considered as the most important stakeholders as they are the significant

customers of a TES compared to other stakeholders. Students are the prime users of the TES in order to prove themselves as competent technical professionals. Their satisfaction is an important determinant factor to enhance quality of education. The main objective of a TES is the retention of students in the institute through the development of methodologies for improving quality of education/research and establishing a brand of their own. The objective can be achieved by focusing on key areas that need improvement through measurement of expectation and perception level of the students.

Similarly, alumni stay connected with their alma mater, classmates, friends and faculties. The institute fosters life long learning through its various programs to help alumni to be successful in their professional pursuits. Alumni association is an important appendage of an institute. Usually, they unite annually to discuss the future prospects of the institute. They take interest and render supports including financial to upgrade the quality of education in the institute. Other important stakeholders in TES are recruiters and parents. Recruiters absorb the quality students of an institute in their organization whereas the parents supply the students to be imparted quality training in an institute.

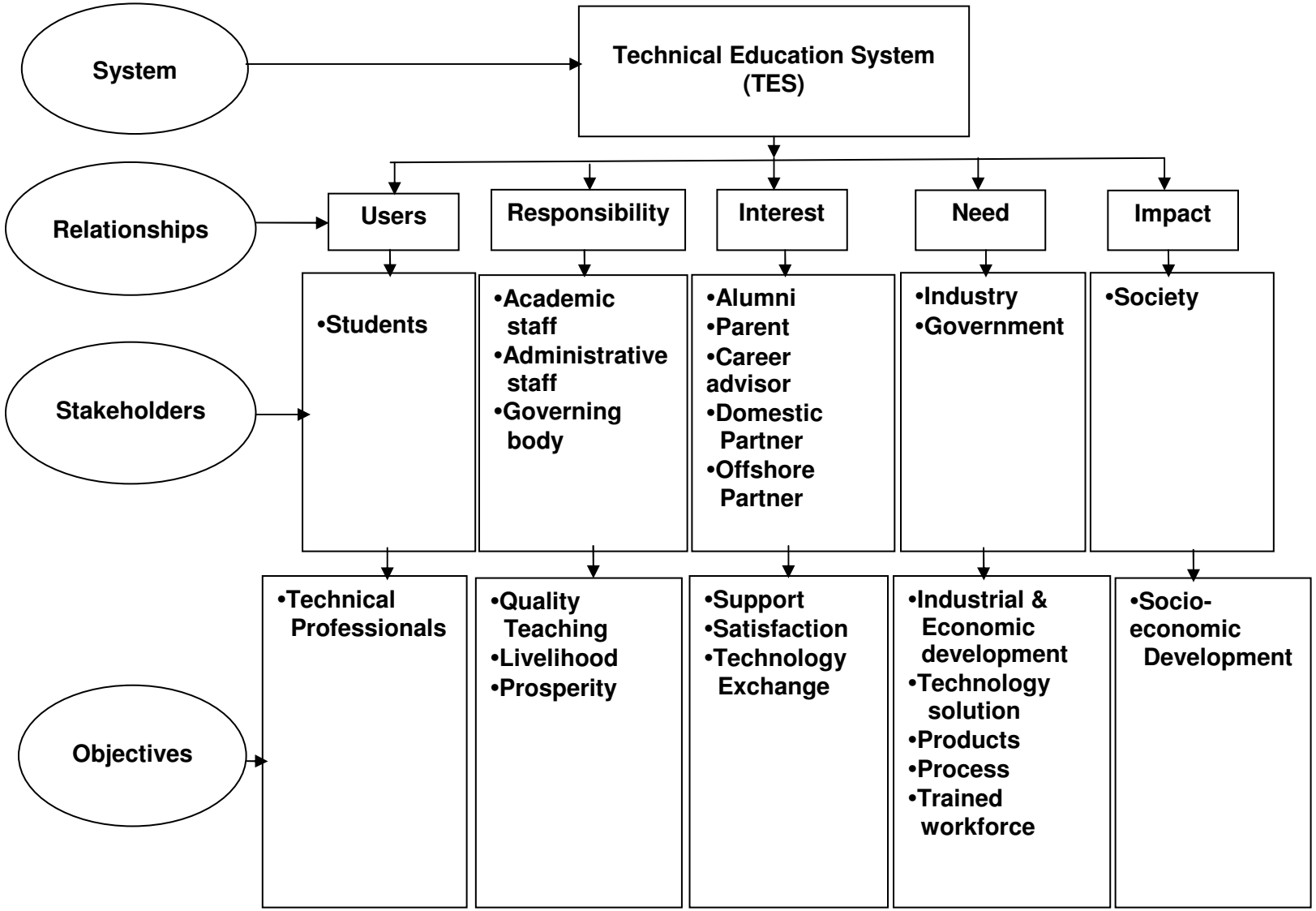


Figure 3.1: Stakeholders and their relationship with the TES

3.3 Quality of Education and its Measurement

Quality in an education sector largely depends upon the expectations and perceptions of various stakeholders associated with it. For assessing education quality, different indictors may be considered to give information about the performance of an educational institution in different aspects of input, process and outcome. Based on different conceptions to achieve the education quality, different people may use different indicators and different strategies to accomplish education quality. The focus of these indicators may not necessarily include all aspects of the input, process and outcome of an educational institution. In order to understand the complex nature of education quality and to develop management strategies for achieving it, several service quality measuring instruments have been developed. The most widely used instrument for measuring service quality is the 'SERVQUAL' [4]. It is based on the conceptualization of service quality as the difference between customer's expectations and perceived performances. In other words, the quality is assessed by the gap between the expectation and perception (P-E gap) of customers. It consists of twenty-two pair of items both for expectations and perceptions measured along the five key dimensions viz., tangibles, reliability, responsiveness, assurance and empathy. The authors claim that the instrument is generic in nature that may be used for measurement of service quality in any service sector including education sector but with some minor modifications as relevant to the service sector considered [4]. Besides 'SERVQUAL', another instrument known as 'SERVPERF' is developed considering only the perception of the customers [5]. Abdullah has proposed 'HEdPERF', a measuring instrument in higher education sector and compared with 'SERVPERF' [7]. Several other service quality measuring instruments with modified items and dimensions have been developed by various researchers suitable to different service sectors. [171,178]. Thus, the quality can be measured with a set of quality items that may be very different from the other standard service quality measurement instruments.

3.4 Development of EduQUAL

The instrument for service quality measurement, 'SERVQUAL', is widely used by the researchers because of its simplicity, possession of simple structure and capability of generalization. The dimensions of a measuring instrument vary with different service settings since the quality of service basically depends on the human behavior. For example, 'empathy' and 'responsiveness' are significant in education sector whereas 'reliability' is important in banking sector. In the same way, the components of quality in a tourism sector are quite different from those of a fast food restaurant. Therefore, it is difficult to define quality of service precisely. Thus, the generalization of quality control and improvement of service sector poses difficulties due to the diversity of its components. Sometimes, numbers of dimensions or items are modified to suit a particular application [171,178]. In education sector, the perception of service quality is a complex composition to analysis because of the persistence of intangibility and lack of physical evidence. TES is characterised by a multiple stakeholder situation with different backgrounds and varied behavioral patterns. An attempt has been made to propose a new instrument for measuring technical education quality in India known as 'EduQUAL' using 'SERVQUAL' as a basis for evaluate the quality at an aggregate level fitting to most of the important stakeholders

Accepting the fact that an educational system caters to the needs of a large number of stakeholders, the students have been treated as the internal customer and alumni, parents and recruiters as the external customer. Each of these groups has diverse expectations and perceptions that need to be prioritized and reconciled. The variables and items for service quality for each stakeholder are conceptualized to identify their needs. To address this issue, a group of experts in the field of technical education system have been consulted. Considering the views of the experts and the quality items mentioned in the literature, a set of items relevant to technical education in India containing forty three survey items is prepared (Table 3.1).

Table 3.1: Requirements of the Stakeholders (Service Items)

Service Items	Source
1.Problem solving skill	[188]
2.Well equipped Laboratories with modern facilities	[188-191]
3.Training on state of the art technology	Proposed by experts
4. Effective office management	[188]
5.Knowledge of official procedures	[188]
6.Cleanliness, orderliness, systematic and methodical	Proposed by experts
7.Adequate facilities/infrastructure to render service	Proposed by experts
8.Faculty expertise	[188, 191]
9.Adequacy of subject teacher	[188]
10.Good communication skill of academic staff	Proposed by experts
11.Comprehensive learning resources	Proposed by experts
12.Training in a well equipped communication laboratory	Proposed by experts
13.Adaptability to modern techniques	Proposed by experts
14.Design of course structure based on job requirement	Proposed by experts
15.Adequacy of supporting staff	[188]
16.Instructional/educational leadership	[183, 192-195]
17.Effective classroom management	[196-198]
18.Opportunities for campus training and placement	[199]
19.Information sharing and exchange	Proposed by experts
20.Inservice training and development of supporting staff	Proposed by experts
21.Faculty's rapport with student	[189]
22.Autonomy/freedom of work	[200]
23.Recognition of students faculty/staff	[197]
24.Courteous and willingness to help	[188]
25.Appropriate classroom hours	[201]
26.Maximum learning time	[192]
27.Academic, residential and recreational facilities	Proposed by experts
28.Aesthetic view of facilities	Proposed by experts
29.Encouragement for sports, games and cultural activities	Proposed by experts
30.Enhancement of knowledge	Proposed by experts
31.Extra academic activities	Proposed by experts
32.Adherence to schedule	[188]
33.Clarity of course objectives	Proposed by experts
34.Adherence to course objectives	Proposed by experts
35.Practical orientation in education	[188]
36.Faculty available regularly for students' consultation	[191]
37.Prompt service of the supporting staff	Proposed by experts
38.Ease of access to the institution	[188]
39.Close supervision of students' work	[191]

40.Proper monitoring system and evaluation procedure	[199]
41.Record keeping on performances	[196]
42.Transparency of official procedure, norms and rules	[202]
43.Sense of social obligation	Proposed by experts

3.4.1 Data Collection

Data are collected from students, alumni, parents and recruiters of different technical institutions (both private and government) across India through e-mail/postal mode/personal contacts by attaching a sample questionnaire comprising of forty three items for expectations as well as perceptions related to quality of service delivered by the organisation. The detailed questionnaire is shown in Appendix 3.1. The respondents are requested to answer in a Likert-type scale from 1 to 7 (1, strongly disagree and 7, strongly agree). A final question whether the stakeholders will recommend their friends and relatives to study in this institute is asked and treated as the output of the forty-three questions. While data collection, it is assumed that weightage for all the items is same i.e. equal to one. Similarly, it is assumed that all the stakeholders are equally important. The lists of institutions, students, alumni, and industries are collected accessing through different websites and personal contacts. Probability as well as non-probability sampling is used for random selection of study units. In probability sampling, stratified random sampling is used whereas convenience and judgmental sampling is used for non-probability sampling. Stratified sampling uses random selection of study units from various groups based on similarity in certain characteristics. In non-probability convenience sampling, the study units (here institutions and stakeholders) that happen to be available at the time of data collection are selected for the purpose of convenience. Non-probability judgmental sampling considers different elements of survey design while deciding upon the study units. The detail information of survey design is shown in Table 3.2.

The survey is conducted through different mode of collecting responses over a period of six months (from December, 2004 to June, 2005). It is carried out in four zones of the country viz., east, west, north and south. For students' survey, a total of 589 questionnaires are sent and 448 responses (76%) are received.

Responses are screened based on completeness, rational scoring and adherence to scale and finally 408 (nearly 69%) responses are considered for further analysis. For alumni's survey, 497 questionnaires have been sent, 257 responded (52%) and the usable responses are 250 (nearly 50%). Similarly, for parents' survey, 478 questionnaires are sent and 262 responses (55%) are received out of which 246 (52%) are used for analysis. For recruiters, a total of 286 questionnaires are sent, 124 responses (43%) are received and 120 responses are considered for further analysis.

3.4.2 Data Analysis

After collecting all the data the process of analysis begins. According to Yin data analysis involves examining, categorizing, tabulating or otherwise recombining the collected data [188]. Miles and Huberman define data analysis as consisting of three concurrent flows of activity: data reduction, data display and conclusion drawing / verifications [189]. The data reduction stage of the analysis helps the researcher to make the data sharp, sorted, focused, discarded and organized in order to be able to draw and verify conclusions. The data display is a way to organize and compress the reduced data so that it will make it easier to draw conclusions. In the conclusions drawing and verification the researcher notes regularities, patterns, explanations, possible configurations, casual flows and propositions. In the next section these three stages will be employed to the collected survey data.

Table 3.2: Details of Questionnaire Survey

Stakeholders	Mode of Obtaining Responses	East		West		North		South	
		Questionnaire Sent	Response obtained	Questionnaire Sent	Response obtained	Questionnaire Sent	Response obtained	Questionnaire Sent	Response obtained
Students	Postal	25	08	10	02	18	06	25	11
	E-mail	52	31	76	54	33	21	112	87

	Personal Contacts	158	158	20	20	15	15	45	45
Total		235	**197**	106	**76**	66	**32**	182	**143**
Alumni	**Postal**	23	06	15	02	20	05	32	10
	E-mail	189	113	65	26	54	32	78	42
	Personal Contacts	14	14	-	-	02	02	05	05
Total		226	**133**	80	**28**	76	**39**	115	**57**
Parents	**Postal**	86	38	43	24	32	10	44	17
	E-mail	42	16	57	38	85	52	63	41
	Personal Contacts	18	18	05	05	-	-	03	03
Total		146	**72**	105	**67**	117	**62**	110	**61**
Recruiters	**Postal**	25	05	35	11	22	08	25	06
	E-mail	13	04	72	29	27	12	48	30
	Personal Contacts	10	10	02	02	03	03	04	04
Total		48	**19**	109	**42**	52	**23**	77	**40**

Note: Total number of questionnaire sent: 1850; Total number of responses received: 1091; Total number of usable responses: 1024; Percentage of responses received: 59%; Percentage of usable response: 56%

3.4.3 Data Reduction, Data Display and Conclusion/Verification

The useful responses (1024) are tested to examine validity and reliability of the scale so as to obtain a quantitative and statistically proven identification of requirements of the stakeholders. The test for quantitative validity was conducted by factor analysis of the forty three proposed variables using the Principal Component Method followed by varimax rotation to ensure that they are important and suitable for the model using SPSS 14.0 software. The algorithms for Principal Component Method factor analysis and varimax rotation are given in Appendix 3.2 and 3.3 respectively. Twenty eight items that loaded more than 0.5 are kept under five dimensions viz., **Learning Outcomes, Responsiveness, Physical Facilities, Personality Development and Academics** as shown in Table 3.3. Twenty-eight items under five dimensions constitute various relevant variables for the proposed instrument, 'EduQUAL', to measure education quality in a technical education system. The fifteen items that failed to get loaded more than 0.5 (listed as effective office management, knowledge of official procedures, adequacy of supportive staff, instructional/educational leadership, information sharing and exchange, faculty's rapport with students, autonomy/freedom of work, in service training and development of faculty and supporting staff, appropriate classroom hours, maximum learning time, clarity of course objectives, adherence to course objectives, ease of access to the institution, proper monitoring system and evaluation procedures, record keeping on performance are deleted from further consideration. Percentage of total variance explained is found to be 75% that is an acceptable value for the principal component varimax rotated factor-loading procedure [190].

The internal consistency or the reliability of the actual survey data of stakeholders (students, alumni, parents and recruiters) is tested by computing Cronbach's Alpha using SPSS 14.0 software. The values of alpha for five dimensions are 0.860, 0.752, 0.909, 0.897 and 0.861 respectively and the combined alpha value for all the items is 0.950 (Table 3.4). Since values of alpha are well exceed the obligatory requirement of 0.70 or above, it demonstrates internal consistency of the established scales [191]. The value of Kaiser-Meyer-

Olkin (KMO), which is a measure of sampling adequacy, is found to be 0.782. This indicates that the factor analysis test has proceeded correctly and the sample used is adequate because the minimum acceptable value of KMO is 0.5 [192]. Therefore, it can be concluded that the matrix did not suffer from multicollinearity or singularity. The results of Bartlett test of Sphericity shows highly significant (sig. = 0.000) implicating correctness and suitability of factor analysis processes for testing multidimensionality [192]. Thus, the statistical and factor analysis tests has resulted in proposed items and dimensions of the instrument of 'EduQUAL' are sound enough to measure the service quality in a technical education system and hence can be used for further analysis.

Table 3.3: Factor Analysis of EduQUAL Items

Dimensions	Items	F_1	F_2	F_3	F_4	F_5
Learning Outcomes	1. Training on state-of-the art technology.	0.809				
	2. Practical orientation in education.	0.779				
	3. Adaptability to modern techniques.	0.690				
	4. Design of course structure based on job requirements.	0.644				
	5. Problem solving skills.	0.625				
	6. Sense of social obligation.	0.556				
Responsiveness	7. Prompt service at service departments.		0.856			
	8. Courteousness and willing to help.		0.739			
	9. Cleanliness, orderliness, systematic and methodical		0.695			
	10. Transparency of official procedure, norms and rules.		0.556			
	11. Adequate facilities/infrastructure to render service.		0.533			
Physical Facilities	12. Well equipped laboratories with modern facilities.			0.762		
	13. Comprehensive learning resources.			0.752		
	14. Academic, residential and recreational facilities.			0.750		
	15. Aesthetic views of facilities.			0.658		
	16. Training in a well equipped communication laboratory			0.613		
	17. Opportunities for campus training and placement.			0.558		
	18. Effective classroom management.			0.533		
Personality Development	19. Encouragement for sports games and cultural activities				0.874	
	20. Enhancement of knowledge.				0.809	
	21. Adherence to schedule.				0.753	
	22. Extra academic activities.				0.602	
	23. Recognition of the students.				0.527	
Academics	24. Adequacy of subject teachers.					0.856
	25. Available regularly for students' consultation.					0.785
	26. Close supervision of students work.					0.632
	27. Expertise in subjects and well organized lectures.					0.583
	28. Good communication skill of academic staff.					0.548

Note: (1) F_1: Learning Outcomes, F_2: Responsiveness, F_3: Physical Facilities, F_4: Personality Development and F_5: Academics.
(2) Figure under each column represent loading factors for items

Table 3.4: Test for Reliability (Cronbach Alpha)

Dimensions of EduQUAL	Alpha for each dimension	Alpha for total survey data
1. Learning Outcomes	0.860	0.950
2. Responsiveness	0.752	
3. Physical Facilities	0.909	
4. Personality Development	0.897	
5. Academics	0.861	

It is concluded from the results that the instrument consists of twenty eight items classified into five dimensions

(1) Learning Outcomes: ability to provide the promised service dependably and accurately

(2) Responsiveness: willingness to help customers, provide prompt service

(3) Physical Facilities: physical facilities, equipment, personnel and communication material

(4) Personality Development: overall development of students' personality, enhancement of knowledge

(5) Academics: expert faculties, individualised attention to the customer

The theoretical framework of this research has been presented in the Figure 3.2 below.

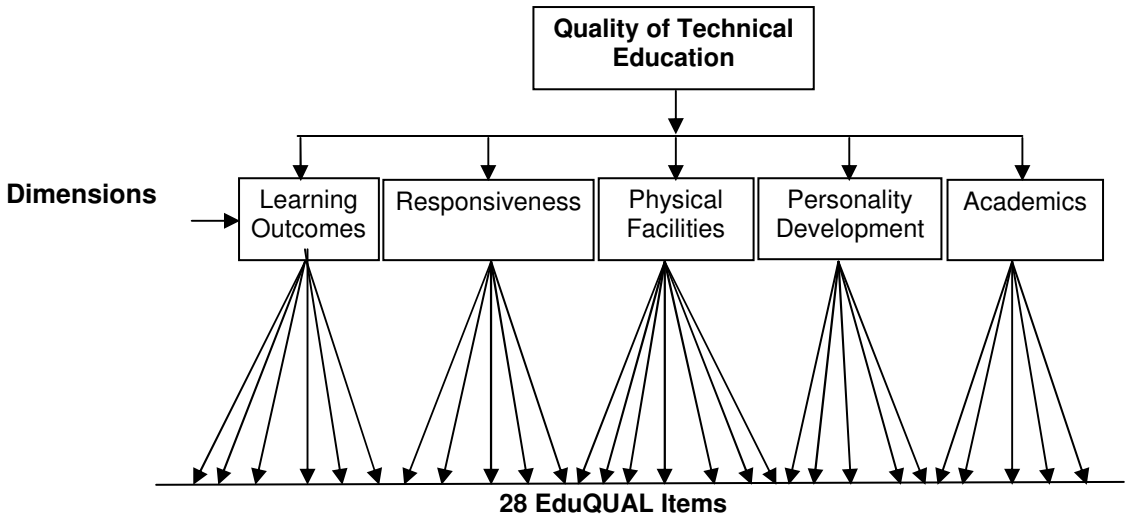


Figure 3.2: EduQUAL Items and Dimensions

3.4.4 Relative Importance of 'EduQUAL' Items and Dimensions

After data reduction and statistical analysis conducted in the previous section, it is concluded that, twenty-eight service items are important for improving quality in a TES relevant to the important stakeholders such as students, alumni, parents and recruiters. These twenty-eight service items are grouped into five dimensions viz., Learning outcomes, Responsiveness, Physical Facilities, Personality Development and Academics. The actual responses of the stakeholder are analyzed in this section in order to gain an insight about the relative importance of items and dimensions of 'EduQUAL' for each stakeholder. For these analyses, only the perceptions of the stakeholders are taken into consideration as this has a greater impact on the quality of service [5,193,194]. Perceptions of the stakeholders are treated as response score. The histograms below depict the details of the analysis for each stakeholder (Figures 3.3, 3.4, 3.5 and 3.6).

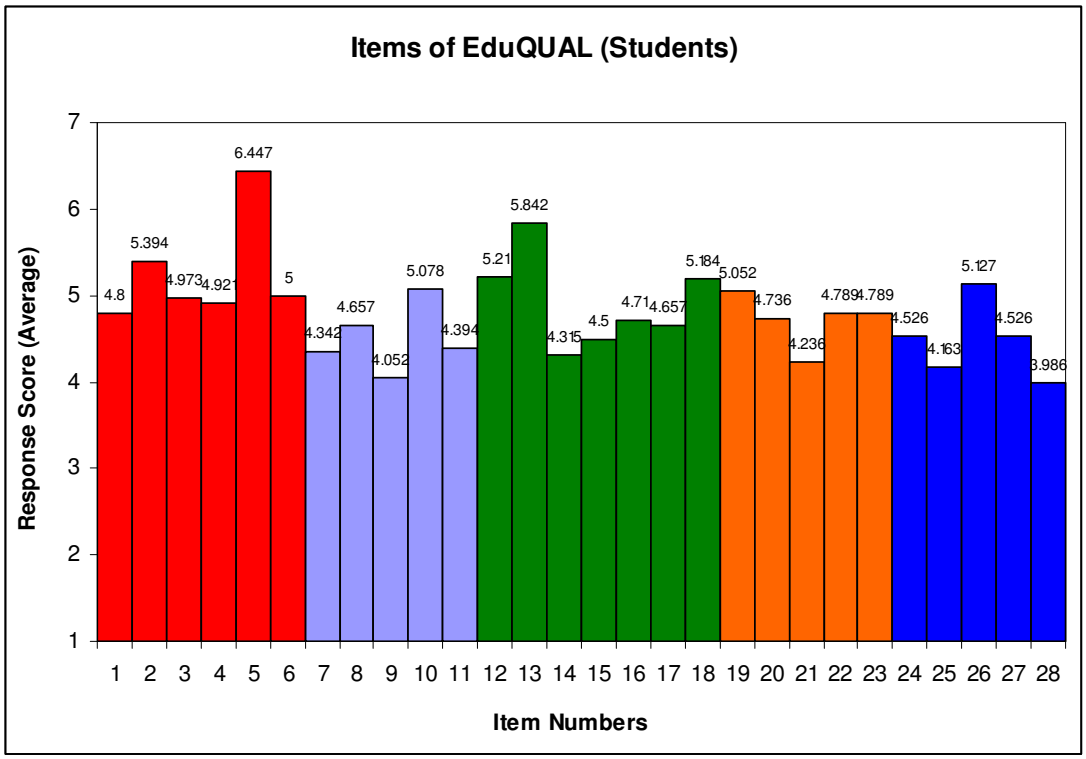


Figure 3.3: Average Response Score of Students for all the EduQUAL Items

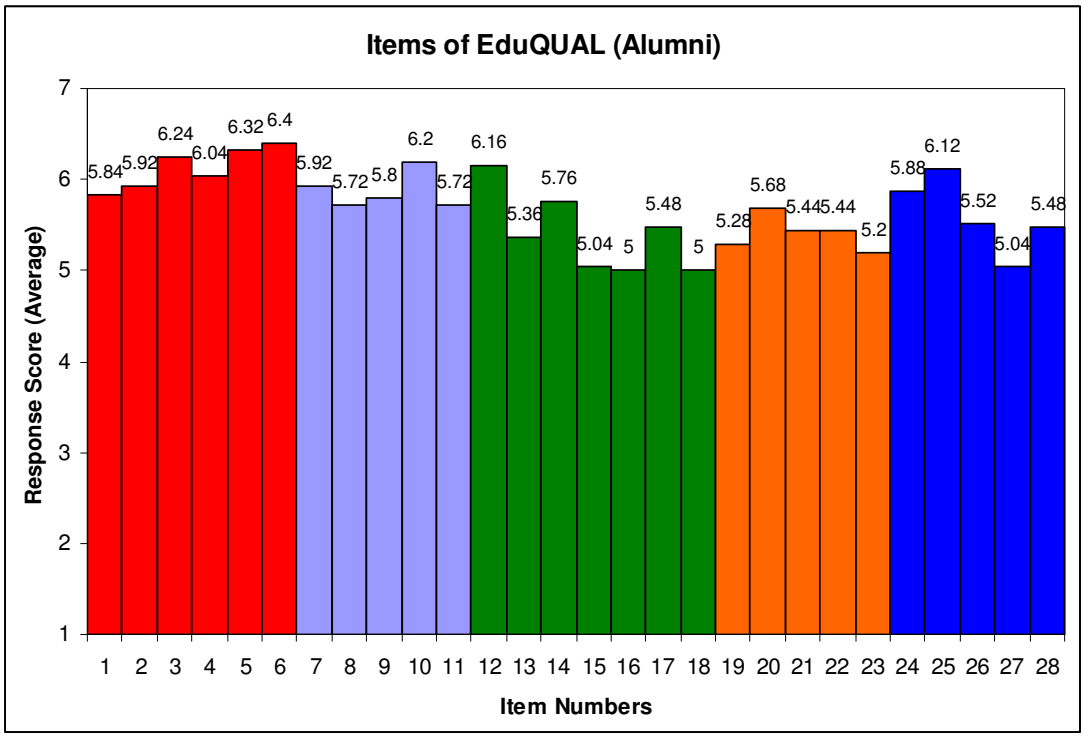


Figure 3.4: Average Response Score of Alumni for all the EduQUAL Items

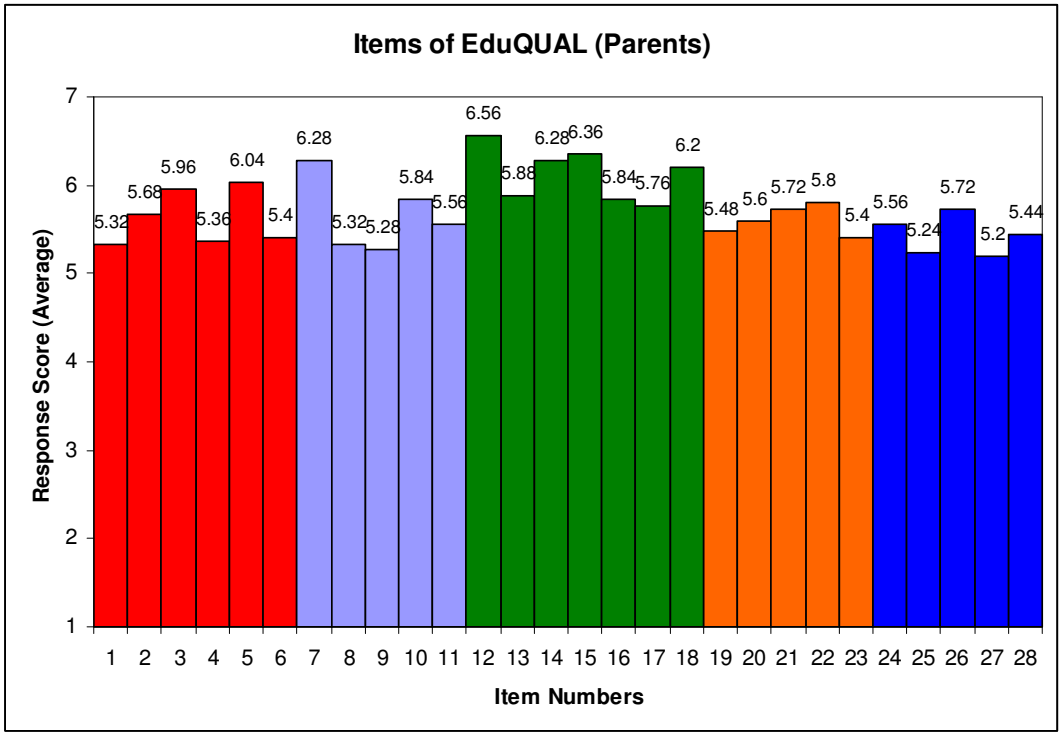


Figure 3.5: Average Response Score of Parents for all the EduQUAL Items

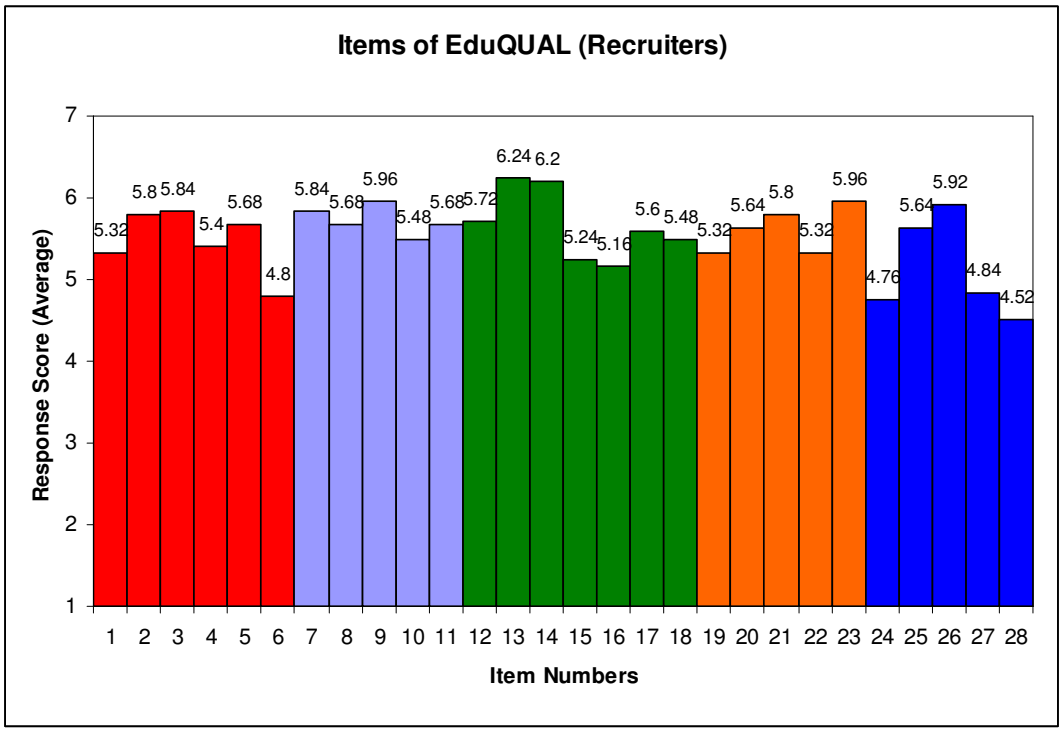


Figure 3.6: Average Response Score of Recruiters for all the EduQUAL Items

In the above figures, the average response score of students, alumni, parents and recruiters respectively for the twenty eight EduQUAL items are shown as histograms. In the dimension **'Learning outcome'** (item number 1-6), the highest response is for the item numbers 5 (problem solving skill), 6 (sense of social obligation), 5 (problem solving skill) and 3 (adaptability to modern techniques) as per the stakeholders students, alumni, parents and recruiters respectively. The items that receive lowest response is item number 1 (training on state-of-art technology), 1(training on state-of-art technology), 1(training on state-of-art technology) and 6 (sense of social obligation) as per the stakeholders students, alumni, parents and recruiters respectively. Thus, all the stakeholders, except recruiters, perceive that the training imparted by the institutions is not modern and up to the mark of the international standard.

Considering the dimension **'Responsiveness'** (item numbers 7-11), the highest scores are given for item number 10, 10, 7 and 9 by students, alumni, parents and recruiters respectively. The lowest score assigned by the above

stakeholders are item number 9, 8 & 11, 9 and 10 respectively. This signifies that the students and alumni perceive less for item number 9 (cleanliness, orderliness, systematic and methodical), parents perceive less for item number 8 (courteousness and willing to help) and 11(adequate facilities / infrastructure to render service). For recruiters, item number 10 i.e. transparency of official procedure, norms and rules seems to be less focused area in the institutions.

The **'Physical Facilities'** (item number 12-18) of the institutions have been given different score by the different stakeholders. The highest responses for the four stakeholders are for item number 13, 12, 12 and 13 respectively. But the lowest perceptions score assigned by the stakeholders may be important criteria for the improvement of service. Here the students, alumni, parents and recruiters perceive less for the item numbers 14, 16 & 18, 17 and 16 respectively. Students experience some deficiencies in the facilities given to them such as residential and recreational facilities. The alumni and recruiters feel that better communication skill of the students must be developed through proper training so that their ability to communicate in actual field of work can improve.

For the dimension **'Personality Development'** (item number 19-23), the highest score assigned by students, alumni, parents and recruiters are for item number 19, 20, 22 and 23 respectively. The minimum score assigned to item numbers 21, 23, 23 and 19 & 22 respectively. The recruiters emphasize more on the extra academic activities like sports and games, the alumni and the parents consider the importance of student's recognition in the technical educational institutions. The students have a general opinion that the institutions do not adhere to the schedule properly.

Considering **'Academics'** dimension (item numbers 24-28), the stakeholders assign highest score to items 26, 25, 26 and 26 respectively. The item numbers those are given the lowest response by the stakeholders are 28, 27, 27 and 28 respectively. The students believe that good communication skill of the academic staff may enhance their knowledge in a better way. The recruiters also have the same opinion because they need the students having depth of knowledge in the subjects. The alumni and the parents perceive the view that the

faculties should have expertise in the subject and their lectures must be well organized.

To accomplish an overall picture of the survey response for the four stakeholders viz., students, alumni, parents and recruiters, a comparative study of the average response score of the stakeholders for 'EduQUAL' is presented in Figure 3.7.

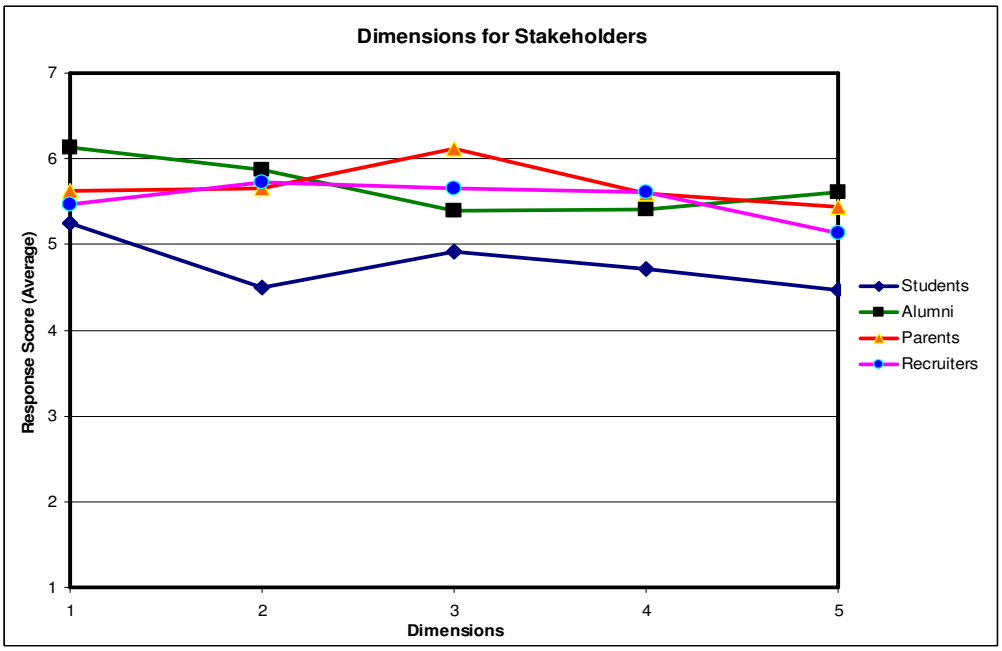


Figure 3.7: A Comparison of Five Dimensions of EduQUAL for all Stakeholders

It is evident from Figure 3.7 that for **students**, the minimum score is for dimension 2 (Responsiveness) and the maximum score is for dimension 1 (Learning outcomes). The other three dimension scores being 4.916, 4.720 and 4.465 respectively for 'Physical facilities', 'Personality development' and 'Academics'. Therefore, the above responses recounts that the students feel that the responsiveness of the service department in an institute must be increased in order to improve the quality of education. For **alumni**, the minimum and maximum response rate in an aggregate level is for dimension 3 (Physical Facilities) and dimension 1 (Learning outcomes). The alumni consider that the physical facilities such as modern laboratories, residential and recreational

facilities and training and placement must be focused and improved on a priority basis by the administrator of TES in order to improve the overall quality of education. The lowest and the highest score for the **parents** average response goes to dimension 5 (Academics) and dimension 3 (Physical Facilities) respectively. The parents find that the physical facilities that are available in institution are sufficient for their wards but they feel that some lacuna is there in the academic area of the institute. The institute must have a good number of faculties with expertise in the subjects and their teaching should be well organized. This is because the parents are more interested about the academic quality of the institute so that their ward can acquire more knowledge and get better placement opportunity. Finally, for **recruiters**, the lowest and highest average response is for dimension 5 (Academics) and dimension 2 (Responsiveness). The recruiters also require a richer product from the educational institutions, which can be achieved by imparting better knowledge to the students through improved academic activities.

From the above discussions it is noted that sequence of prioritization of dimensions as per the perceptions of the stakeholders are significantly different from each other. Table 3.5 summarizes the prioritization of for all stakeholders considered in this study. The arrow indicates move from higher to lower prioritized dimensions.

Table 3.5: Prioritization of Dimensions

Prioritization of the Dimensions	Stakeholders			
	Students	**Alumni**	**Parents**	**Recruiters**
↓	Learning Outcomes	Learning Outcomes	Physical facilities	Responsiveness
	Physical facilities	Responsiveness	Responsiveness	Physical facilities
	Personality development	Academics	Learning Outcomes	Personality development
	Academics	Personality development	Personality development	Learning Outcomes
	Responsiveness	Physical facilities	Academics	Academics

3.5 Conclusions

In this chapter, a detailed general methodology for designing an instrument for measuring service quality has been proposed. The methodology applied to Indian technical education to develop the instrument is known as 'EduQUAL'. The design of instrument for service quality measurement is framed by considering the responses from important stakeholders such as students, alumni, parents and recruiters. The responses are collected through a questionnaire survey containing forty-three service quality items relevant to an educational system. The survey data thus collected are analyzed through factor analysis and statistical tests in order to get a robust instrument. After factor analysis, twenty-eight quality items loaded more than 0.5 with five factors. The five dimensions so evolved have been named as 'EduQUAL' dimensions. Thus, 'EduQUAL' consists of twenty eight service quality items classified into five dimensions viz., Learning outcomes, Responsiveness, Physical Facilities, Personality Development and Academics. Finally, in order to get an insight of the 'EduQUAL' items and dimensions, the actual survey data are further analyzed statistically. The average responses of the stakeholders are considered for examining the perceptions of the service quality in TES. The histograms (Figures 3.3, 3.4, 3.5 and 3.6) show that the lowest perceptions of the students and parents for the items are included in dimensions 'responsiveness' and 'academics' indicating the fact that they are concerned more about the academic facilities provided in the institutions and the responsiveness of the administrative staff. The alumni of the institutions are bothered about service quality items present in 'physical facilities' and 'academics' dimensions. The recruiters rate lowest score for the items included in the dimensions 'learning outcomes' and 'academics' suggesting improvement in these dimensions in order to increase the problem solving skills of the products of the institutions (students). It is interesting to note that all the stakeholders emphasize to improve the service quality items in 'academic' dimension highlighting the importance of core area in an educational institution. A dimension-wise analysis of average response score of the stakeholders indicates slightly different results (Figure 3.7). The lowest

response score has been observed for the dimension ‘academics’, both for parent and the recruiters. The students and alumni perceived least for the dimensions ‘responsiveness’ and ‘physical facilities’ respectively indicating that there is a need to concentrate on these dimensions to improve the service quality in TES.

The future directions of the research include the consideration of other stakeholders in a TES and the collection of more exhaustive data across the country. Although this study demonstrates the methodology for developing an instrument for measurement of service quality in education sector at an aggregate level, the approach is quite general and can be applied to any specific organisation. However, we recommend identifying the customers at the first step and then meticulously finding out their requirements. The next step is to design a measuring instrument for particular application and that can only be used only after validating through statistical tests.

CHAPTER IV

Service Quality Evaluation

4.1 Introduction

Performance measurement provides assessment of an organization how well it is progressing towards its predetermined objectives and helps to identify areas of strengths and weaknesses so that decisions on future initiatives can be made for enhancing various measures. Performance of service is usually characterized as a result of interaction between the customer and the service system including the contact staff, equipment, service environment and facilities. It is this interaction that results in various features of service such as simultaneity of service production and consumption, perishability, heterogeneity and intangibility [40,195-197]. Customer satisfaction in service environment is concerned with the degree of fitness between customer's expectations and perceptions of the service [47,198-200]. As expectations and perceptions of customer vary from sector to sector and even in the same sector at different point of time, it poses difficulty in evaluating the quality of service in a precise manner. Hence, several traditional and soft-computing tools such as statistical analysis, neural networks, rough set, genetic algorithm, fuzzy logic and data envelopment analysis are used to evaluate and optimize the quality of service [14-18].

Among all service sectors, education sector, particularly technical education system (TES) has direct bearing on society for its growth and socio-economic development. One of the key skills required for an engineer is the ability to produce systems that satisfy users' requirements by correct selection, configuration, integration, operation and control of proprietary building blocks. In India, the fact was realized quite early and impulse of creation of centers of technical training came long ago. Today, many engineering colleges and technical universities with different courses in undergraduate, postgraduate and research levels are in existence and compete with each other as well as with the foreign institutes for imparting education. All India Council of Technical Education (AICTE) registers 1,346 numbers of engineering colleges till 2003 in various parts of the country with an annual intake capacity of 439,689 in different branches of engineering and technology. However, limited number of state funded institutions and diminishing funding in higher education by government

caused mushrooming of private institutions in India. Therefore, the students have wide option to choose the institution to pursue their interests. As the students bear the complete expenditure of education, they deserve the best education. Therefore, quality has become a competitive weapon for the institutions to serve and attract their primary customers (students).

Higher education in general and technical education in particular, represents too process oriented, intangibility and multiple stakeholder situations. Most of the performance measurement systems of higher educational institutions do not reflect the full range of interested parties (stakeholders) and are not closely linked to the strategic management. Therefore, some authors have proposed the use of a balanced scorecard approach in order to reinforce the importance of managing rather than just monitoring performance [201]. Rapert et al. confirms the importance of expectation of key stakeholders in the educational process while exploring the meaning of quality through students' evaluation of an MBA program using a combination of qualitative and quantitative approach [71]. Temponi analyses the main elements of continuous improvement in higher education addressing to the concerns of academia's stakeholders during the process of its implementation [72]. Lomas emphasised on selection of particular quality management model such as EFQM (European Forum for Quality Management) and TQM (Total Quality Management) for promoting continuous improvement of quality in education [73]. In addition, few studies highlight the method of pedagogy and selection of institutes of higher learning [74,75].

SERVQUAL (and its modified versions), a multiple-item survey instrument, that supports qualitative analysis with quantitative information are still popular among researchers as far as assessment of service quality is concerned and have been applied to different service sectors [4,45,55-57]. The instrument uses five core criteria (dimensions) consisting of twenty-two pairs of components evaluated in a seven point Likert-type scale under which customers decide in evaluating the service quality. The first twenty-two items are designed to measure customer's pre-purchase expectations for a particular service and the other twenty-two items are provided to measure perceived level (perceptions)

after delivery of a service. Service quality is the 'gap' between expectations of a customer from the service provider and the perception of the service experienced by the customer (popularly known as P-E gap). SERVQUAL-based gap model has been effectively used for assessing quality practices for providing guidelines for improvements [202-204]. However, poor reliability and inter-factor correlations of SERVQUAL leads to propose SERVPERF (perception-only model) and HEdPERF (Higher Education PERFormance) for efficient measurement of service quality [5,7].

In addition to popular P-E gap model, two more models such as expectations minus perceptions (or E-P gap model) and expectations and perceptions (E&P) model have been proposed to take care of the preconceived expectations of customers before the service is being delivered [61]. It is observed that E-P model performs best compared to other models when tested using neural networks in an auto-dealership network. The study also demonstrates that neural networks based on back propagation algorithm can be effectively used for modeling and evaluating qualitative and intangible aspects of service quality. Hoefer and Gould used neural approach to predict students' academic performance in business programme whereas Nordmann and Luxhoj applied it for forecasting of service problems in aircraft structural component grouping [22,23]. Tam and Kiang applied a neural approach for predicting failures in banking sector [24]. In this chapter, a methodology based on neural network is proposed for evaluation of service quality in TES with specific relevance to Indian environment.

4.2 Models of Education Quality

Based on the models of organizational effectiveness and institutional effectiveness, seven models of education quality have been proposed in the literature to illustrate the different concepts that can be used to deepen understanding of education quality and develop management strategies [205-207]. These seven models are shown in Table 4.1. Each of these models deals with the different key areas for evaluation of quality. For example, the quality of

the education is measured through the satisfaction levels of its stakeholders in ‘Satisfaction Model’ where as the key areas of evaluation are leadership, social interaction and classroom climate in ‘Process Model’. Out of the seven education models, ‘Satisfaction Model’ has been considered here to evaluate the education quality in the technical educational institutions because variation of satisfaction level among the stakeholders can be accounted for.

According to this model, education quality is defined as the satisfaction of strategic constituencies (stakeholders) of an educational institution for its survival. The education quality should be determined by the extent to which the performance of an educational institution can satisfy the needs and expectations of its powerful constituencies such as teachers, management board members, parents, students, alumni, recruiters, administrates [208]. Education quality primarily depends on the expectations and perceptions of concerned constituencies. Therefore, it is difficult for all institutes to achieve it and satisfy the needs of multiple constituencies. Furthermore, the objective evaluation of quality achievement is often technically difficult and conceptually controversial. Therefore, satisfactions of powerful constituencies are frequently used instead of some objective indicators as the critical element to assess quality in educational institution. For the present research, four important indicators of education quality (stakeholder) viz., students, alumni, parents and recruiters have been considered. The students are treated as the primary customer and others (alumni, parents and recruiter) are treated as secondary customers of the TES.

Table 4.1: Models of Education Quality

Sl.No	Model	Conception of education quality	Conditions for model usefulness	Indications/key areas for quality evaluation (with example)
1	Goal and specification model	Achievement of stated institutional goals. Conformance to given Specifications.	When institutional goals and specifications are clear, consensual, time –bound and measurable. When resources are sufficient to achieve the goals and conform to the specifications.	Institutional objectives, standards and specifications listed in the programme plans, e.g. academic achievements attendance rate, dropout rate.
2	Resource – input model	Achievement of needed quality resources and input for the institution	When there is a clear relationship between inputs and output. When quality resources for the institution are scarce.	Resources procured for institutional functioning, e.g. quality of student intake, facilities, financial support.
3	Process model	Smooth internal process and fruitful learning experience	When there is a clear relationship between process and educational outcomes.	Leadership, participation, social interactions, classroom climate, learning , activities and experiences.
4	Satisfaction model	Satisfaction of all powerful constituencies	When the demands of the constituencies are compatible and cannot be ignored.	Satisfaction of education authorities, management board, administrators, teachers, parents, students, alumni, recruiters.
5	Legitimacy model	Achievement of the institution's legitimate position and reputation.	When the survival and demise among education institutions must be assessed. When the environment is very competitive and demanding.	Public relations, marketing, public image. Reputation, status in community, evidence of accountability.
6	Absence of problem model	Absence of problems and troubles in the institution	When there are no consensual criteria of quality but strategies for improvement are needed.	Absence of conflicts, dysfunctions, difficulties, defects, weaknesses, troubles.
7	Organizational learning model	Adaptation to environmental charges and internal barriers. Continuous improvement.	When institutions are new or charging When the environment charge cannot be ignored.	Awareness of external needs and charges, internal process monitoring, programme evaluation, development planning, staff development.

4.2.1 Tools for Evaluation of Service Quality

Quantitative measurement of service quality is extremely difficult because of the involvement of human behavioral aspects and the absence of precise numerical data. Some of the approaches of service quality measurement are outlined as follows:

- **Statistical analysis:** This is the most mature of all prediction and evaluation techniques and easiest to understand. But it is difficult to apply in conditions of non-linearity, multiple outliers, and non-numerical data typically found in service sector.
- **Artificial Neural Networks (ANN):** This technique is an attempt to reflect the way the human brain works in recognizing patterns by developing mathematical structures with the ability to learn. It is the basis for development of non-linear predictive models that are capable of learning how different combinations of variables affect the data set.
- **Machine learning techniques such as genetic algorithms and fuzzy logic:** Machine learning techniques possess the ability to derive meaning from complicated and imprecise data. It can find more complex regularities or dependencies that include both numerical and logical conditions and are far too complex to be observed by humans or discovered by means of conventional statistical analyses.
- **Rough Set.** This is a new soft computing approach for data analysis which emphasizes on classifying objects of interest into similarity classes (clusters) containing objects which are indiscernible with respect to some features in order to find hidden pattern in data.
- **Analytical Hierarchy Process (AHP):** The analytic hierarchy process (AHP) is a multi-attribute decision modeling (MADM) used successfully to investigate in many different problems of manufacturing as well as in the service sectors. The AHP consists of four major steps for decision making process viz. (1) deciding the criteria for selection (2) rating the relative importance of these criteria using pair-wise comparisons (3) rating each potential choice relative to each other by performing pair wise

comparisons, and (4) combining the ratings derived in steps 2 and 3 to obtain an overall relative rating for each potential choice.

- **Quality Function Deployment (QFD):** Quality Function Deployment (QFD) is used to convert customer requirements into "quality characteristics" and develop product design of high quality by systematically deploying the relationships between customer requirements and engineering characteristics beginning with the quality of each functional component and extending the deployment of the quality of each part and process. The objectives in QFD are to identify (1) the customer (2) the customer wants and (3) to meet the customer's requirements.
- **Data Envelopment Analysis (DEA):** It is a methodology that allows management analysts to measure the relative efficiency of each member of a set of comparable organizational units based on a theoretical optimal performance for each organization. For this purpose, the organizational units under analysis are designated as Decision Making Units (DMUs). These DMUs can be separate firms, or they can be separate sites or branches of a single firm or agency. The key advantage of DEA over other methods of performance evaluation is that it allows one to consider a number of outputs and inputs simultaneously regardless of whether all the variables of interest are measured in common units.
- **Taguchi Method:** Taguchi method is a technique for designing and performing experiments to investigate processes where the output depends on many variables. The Taguchi method avoids the tedious and costly task of running a process using all possible combinations of variables. By systematically choosing certain combinations of variables, it makes possible to separate their individual effects. Unlike traditional Design of Experiments (DOE), it focuses on optimizing design parameters to minimize variation before design phase to hit mean target values for output parameters. Most typical applications of this method have centered around two main areas viz., (1) improving an existing product or service and (2) improving a process for a specific product or service.

- **Decision trees.** This is a conceptually simple mathematical method of analyzing the effect of each event that has successive events (or decisions).
- **Data visualization.** This technique focuses on the process by which complex numerical data are converted into meaningful images by mapping physical properties to the data and taking advantage of human visual systems in the process.

Artificial Neural Networks (ANN) has been employed in this study for the evaluation of 'Satisfaction Model' of TES because it is frequently applied in the literature for modeling the human decision-making process since it is considered to be the brain metaphor of human judgments. It is a potential technique to predict an output, classify a given inputs into a groups (pattern recognition) and incorporates the heuristic criteria [20]. It can also exploit and represent the non-linear relationship between the customer satisfaction and their perception of the service that are the key elements for evaluation of the service such as education sector [21]. Therefore, in this research, ANN has been applied in TES to evaluate the service quality considering four performance models (P-E, P-only, E-P and E&P) for customer satisfaction using their expectations and perceptions of the service [4,5,61].

4.3 Artificial Neural Networks (ANN) as a Modeling Tool

With the advent of modern computer technology and information science, sophisticated information systems can be built that can make decisions or predictions based on information contained in available past data. Such systems are called learning systems and are currently used for the purpose of classification and prediction [209]. Most of the early applications of neural networks have been in systems such as signal stabilizer, word recognizer, process monitor, sonar classifier and risk analyzer. Since neural networks are best at identifying patterns or trends in data, they are well suited for prediction or forecasting needs in the following areas:

- Sales forecasting
- Customer research
- Target marketing
- Risk management
- Data validation
- Industrial process control

Other applications of neural networks found in literature include the fields of aerospace, electronics, telecommunications, manufacturing, medical, banking, securities market, speech recognition, oil and gas exploration, and market research. ANN are also used in few specific paradigm like recognition of speakers in communications, diagnosis of hepatitis, recovery of telecommunications from faulty software, interpretation of multi-meaning Chinese words, undersea mine detection, texture analysis, three-dimensional object recognition, hand-written word recognition and facial recognition.

An Artificial Neural Network (ANN) is an information-processing paradigm that is inspired by the way biological nervous systems, such as the human brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in conjunction to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application such as pattern recognition or data classification through a learning process. Learning in biological systems involves adjustments to the connections that exist between the neurons that are true for ANNs as well.

A neural network consists of a network of neurons. Each neuron is associated with an input vector, a weight vector corresponding to the input vector, a scalar bias, a transfer function and an output vector as shown in Figure 4.1. A neural network may consist of one or more neurons in each layer. In a network, the final layer is called the output layer and all previous layers are called hidden layers. In the hidden layers, the output of a layer becomes the input for the following layer. The transfer function of a neuron converts the input to the

output of the neuron. Multilayer neural networks are quite powerful tools used in solving many different problems. Various types of neural networks are available for different purposes. In this research, we have attempted to use the neural networks technique in the field of education with multilayer back propagation neural network architecture.

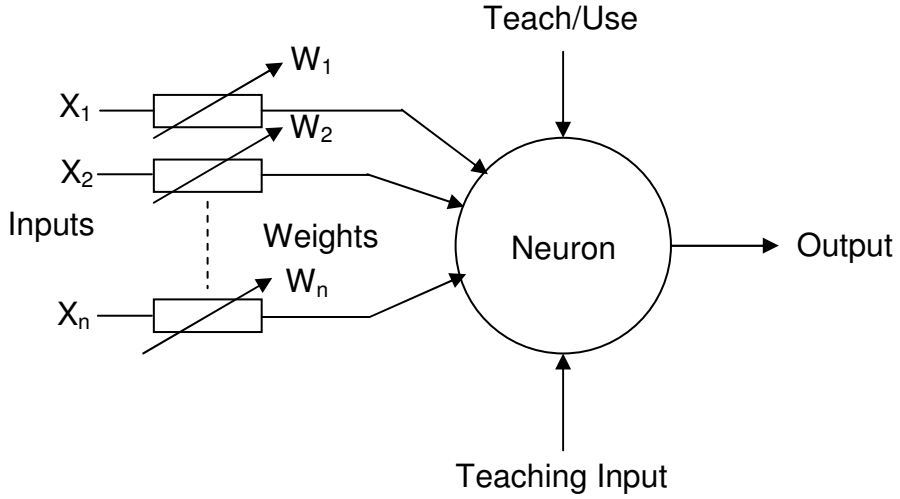


Figure 4.1: A Typical Neuron

4.3.1 The Transfer Functions

The behavior of an ANN depends on both the weights and the input-output function (transfer function) that is specified for the units. There are three main types of transfer functions: (1) Linear (or ramp) (2) Threshold and (3) Sigmoid as shown in the Figures 4.2a, 4.2.b and 4.2.c.

In **linear transfer functions** (Figure 4.2.a), the output activity is proportional to the total weighted output. For **threshold transfer functions** (Figure 4.2.b)**,** the output is set at one of two levels depending on whether the total input is greater than or less than some threshold value. In **sigmoid transfer functions** (Figure 4.2.c), the output varies continuously but not linearly as the input changes. Sigmoid units bear a greater resemblance to real neurons than the linear or threshold transfer functions but all three are considered to be rough approximations.

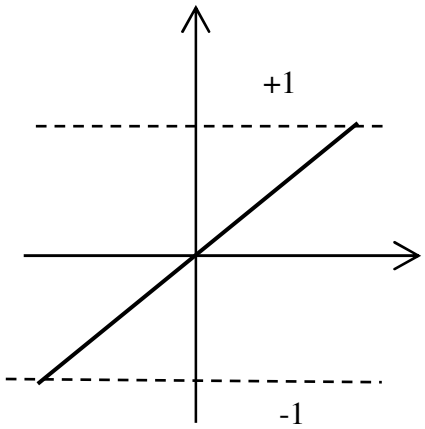


Figure 4.2.a: Linear Transfer Function

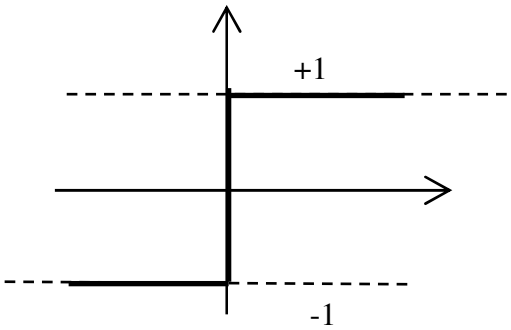


Figure 4.2.b: Threshold Transfer Function

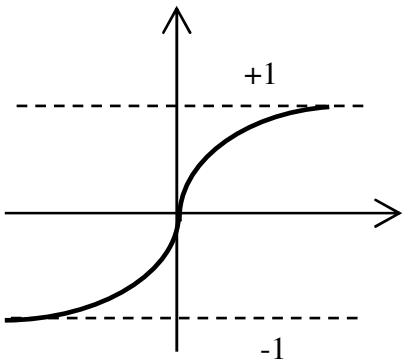


Figure 4.2.c: Sigmoid Transfer Function

Each neuron in the network is a processing element that performs summation and the transfer functions in converting input to output. The summation function evaluates the signed weighted sum of all inputs at a given node. The resulting total input is passed through the transfer or activation function to create the output. Network behavior depends substantially on the

transfer functions of a node. For a typical semi-linear sigmoid function the input (x) is converted to desired output through the equation (4.1) that is used in majority of neural network designs.

$$f(x) = \frac{1}{(1 + e^{-x})} \tag{4.1}$$

4.3.2 Network Layers

The most common type of artificial neural network consists of three groups or layers of units (neurons) - a layer of "**input**" units is connected to a layer of "**hidden**" units, which is connected to a layer of **"output**" units (Figure 4.3). The activity of the input units represents the raw information that is fed into the network while the activity of each hidden unit is determined by the activities of the input units and the weights on the connections between the input and the hidden units. The behavior of the output units depends on the activity of the hidden units and the weights between the hidden and output units. The architectures of ANN may be single-layer or multi-layer. In the single-layer organization, all units are connected to one another. It constitutes the most general case and is of more potential computational power than hierarchically structured multi-layer organizations.

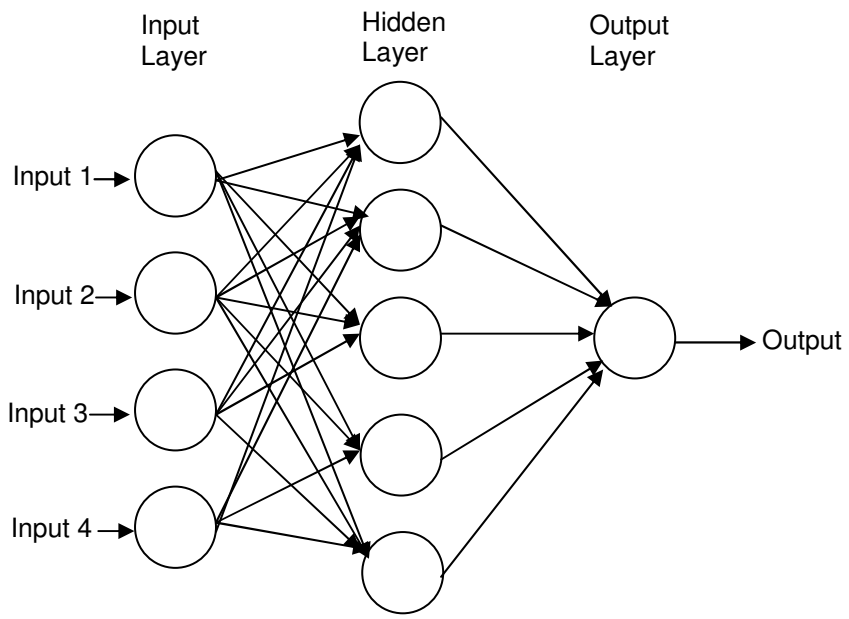


Figure 4.3: A Simple Feed forward Neural Network with Three Layers

4.3.3 Architecture of Neural Networks

There are basically two architectures of neural networks. They are

- Feed-forward networks
- Feedback networks

Feed-forward networks allow signals to travel one way only from input to output. There is no feedback (loops) i.e. the output of any layer does not affect that same layer. Feed-forward networks tend to be straightforward networks that associate inputs with outputs. They are extensively used in pattern recognition. This type of organization is also referred to as bottom-up or top-down.

Feedback networks can have signals traveling in both directions by introducing loops in the network. Feedback networks are very powerful and are complicated. These types of networks are dynamic and their 'state' is changing continuously until they reach an equilibrium point. They remain at the equilibrium point until the input changes and a new equilibrium needs to be found. Feedback architectures are also referred to as interactive or recurrent although the latter term is often used to denote feedback connections in single-layer organizations.

4.3.4 The Learning Process

The memorization of patterns and the subsequent response of the network are known as learning or training process of neural networks. Every neural network possesses knowledge that is contained in the values of the connection weights. Modifying the knowledge stored in the network as a function of experience implies a learning rule for changing the values of the weights. All information is stored in the weight matrix 'W' of a neural network. Learning is the determination of the weights. There are two major categories of neural networks learning:

1. **Fixed network learning** in which the weights cannot be changed i.e. $dW/dt = 0$. In such networks, the weights are fixed according to the problem to solve.
2. **Adaptive network learning** which are able to change their weights i.e. $dW/dt \neq 0$.

All learning methods used for adaptive neural networks can be classified into two major categories:

- Supervised learning
- Unsupervised learning

Supervised learning incorporates an external teacher so that each output unit is told what its desired response to input signals ought to be. During the learning process global information may be required. Paradigms of supervised learning include error-correction learning, reinforcement learning and stochastic learning. An important issue concerning supervised learning is the problem of error convergence i.e. the minimization of error between the desired and computed unit values. The aim is to determine a set of weights that minimizes the error. One well-known method, which is common to many learning paradigms, is the least mean square (LMS) convergence.

Unsupervised learning uses no external teacher and is based upon only local information. It is also referred to as self-organization in the sense that it self-organizes data presented to the network and detects their emergent collective properties. Paradigms of unsupervised learning are Hebbian and competitive learning. Usually, supervised learning is performed off-line whereas unsupervised learning is performed on-line.

4.3.5 The Back Propagation (BP) Algorithm

In order to train a neural network to perform some task, we must adjust the weights of each unit in such a way that the error between the desired output and the actual output is reduced. This process requires that the neural network compute the error derivative of the weights (EW). In other words, it must calculate how the error changes as each weight is increased or decreased slightly. The back propagation algorithm is the most widely used method for determining the EW.

The back-propagation algorithm is easiest to understand if all the units in the network are linear. The algorithm computes each EW by first computing the

EA (difference between the actual and the desired output), the rate at which the error changes as the activity level of a unit is changed. To compute the EA for a hidden unit in the layer just before the output layer, we first identify all the weights between that hidden unit and the output units to which it is connected. We then multiply those weights by the EAs of those output units and add the products. This sum equals the EA for the chosen hidden unit. After calculating all the EAs in the hidden layer just before the output layer, we can compute in the same fashion the EAs for other layers, moving from layer to layer in a direction opposite to the way activities propagate through the network. This is what gives back propagation its name. Once the EA has been computed for a unit, it is straightforward to compute the EW for each incoming connection of the unit. The EW is the product of the EA and the activity through the incoming connection. An Algorithm for Generalized Delta-Rule of BP algorithm is given in Appendix 4.1. This algorithm is known as supervised training of back-propagation algorithm. It has become the accepted standard process in training the multi-layered, feed-forward neural networks [210]. Therefore, we have employed the back-propagation algorithm in this research to analyze the response pattern of stakeholders in the technical education system.

4.4 Evaluation of Education Quality using Neural Networks

It is obvious from discussions in chapter 3 that development of quality measurement instrument for education set up and methodology for assessment of quality is of prime importance for providing guidelines for the administrators of the institutions. The quality indicators must satisfy all the stakeholders involved with the system. In an educational set up, multiple stakeholders viz., students, alumni, parents, recruiters, faculties, supporting staff, government, society and administrators interact with the system in different ways and have diverse expectations. Therefore, the service items are likely to differ amongst stakeholders. The administrators of education set up find it very difficult to fix the norms that suit all the stakeholders. This research attempts to develop a uniform construct (minimum number of items) of service that meet the service

requirement of important stakeholders. Specifically, the study tries to identify the areas of improvement that need to be focussed by management of the organisation to improve quality of education. To address these issues, a survey instrument known as 'EduQUAL', specifically proposed for technical education sector, is used to measure the satisfaction level of different stakeholders.

Basically, network approach used here so as to enable one to address three fundamental issues. Firstly, the consideration of applying neural network adequately for modeling of customer evaluation of service quality in education. Secondly, since neural network is considered as 'brain metaphor' of information processing, it may be possible to get some insight into the issues related to how service quality is being currently measured and evaluated. Thirdly, the study demonstrates effective utilization of neural network models by the service providers for identification and improvements of the quality of service.

In order to establish the quality in TES, the response collected for development of 'EduQUAL' (refer chapter 3) through questionnaire survey from important stakeholders (students, alumni, parents and recruiters) have been analyzed in detail in the following sections.

4.4.1 Network Parameters

The responses obtained from different stakeholders for twenty-eight items in regard to perceptions and expectations pertaining to TES are used to measure the quality through application of back propagation algorithm of neural networks. The back propagation module of a neural network package NeuNet Pro version 2.3 is used for training and testing of survey data due to its fast generalisation capability [211]. The network consists of three layers having desired number of nodes in input (I) as well as hidden layer and a single node in output layer. A single question regarding overall customer evaluation of the service quality is considered as the output. As per the software recommendations, the number of nodes in the hidden layer (H) is decided by the relation as below,

$$H = 2\sqrt{(I+1)} \tag{4.2}$$

Normalization of raw data is carried out to obtain values between 0 and 1 for expressing all data in a common scale. Learning rate less than 0.1 and momentum parameter near to zero are set during the training phase. Seventy five percent of data for each stakeholder are considered for training and the rest data are used for testing. The numbers of correct outputs are noted till the root mean square error (RMSE) is minimised to a reasonable value.

4.4.2 Design of Models

Human decision-making process can be modeled using neural networks as it has the capability to predict an output, classify a given set of inputs into different groups (known as the pattern recognition), and incorporate heuristic criteria [87]. As neural network can effectively exploit and represent the non-linear relationship between the consumer satisfaction and their perception of the service, it can be used for modeling of a customer's decision making [21].

Usually, four models such as perception minus expectation gap (P-E gap), expectation minus perception gap (E-P gap), perception-only (P-only), and expectation and perception (E&P) models are used to predict service quality. However, performance of various models in relation to predictive power of service improvement widely differs depending on to specific application [4,5,47,61]. The deviations in obtaining the best model of service quality are due to the fact that the quality of service varies from one sector to another. For example, the components of quality in a fast food restaurant are very different from those on a railway or a bank or a holiday resort. Therefore, quality of service is much difficult to define precisely because service provider generally provides utility, not objects, as in case of manufacturing sector. The diverse components of service sector make its quality control and improvement more difficult to generalize. The service quality items in the educational sector largely differ that from the auto-dealer network, financial or transportation sector. Thus, neural network models, when tested in a different service sector with different survey items, may indicate significantly different results.

Therefore, in this work, four neural networks models have been designed for the analysis and evaluation of service quality in education with the input data such as customer expectations, perceptions and the gaps.

- **Model-I (P-E gap model):** In this network model, the input is defined using the traditional SERVQUAL-based gap that means perceptions of customers minus the expectations [4]. This resulted in twenty-eight input nodes, a hidden layer and an output layer consists of one node representing the overall evaluation of service quality. Using the training sample (75% data), the network is run till root mean square error (RMSE) is minimised. Then, the network is tested with test data (25% data) and finally the percentage of correct outputs is noted.
- **Model-II (P-only model):** The use of perception and expectation gap raised concern among the researchers due to its low reliability and poor inter-factor correlations [5,169,170]. It is argued that perceptions of the customer are more important than the gap between their perceptions and expectations. Therefore, a service quality measuring instrument known as 'SEVPERF' considering only the perceptions of the customers is suggested [5]. In this model, only customer perceptions are used as input to the network. The perception data are trained to obtain the minimum root mean square error and finally tested to get the percentage of correct output.
- **Model-III (E-P gap model):** Generally, it is assumed that most customers enter a service situation with some expectations [61]. These expectations are formed either by previous experiences of the same or similar service, or simply expectations generated by customer independently. So customer usually undertakes a service experience with some preconceived expectations and thereafter develops a perception of that experience. Hence, service quality could be measured as expectations minus perceptions or E-P gap. A positive E-P score implies that customer expectations are more than the perceptions of the customer i.e. the expectations of customers are not met whereas a negative score in this gap indicates the delighted customer. The values of gap for the twenty-eight

items of EduQUAL are used as the input data for this network. The training and testing of the E-P data are carried out in a similar fashion as mentioned earlier.

- **Model-IV (E & P model):** Customer expectations are generally accepted as a part of the service experience but their exact role in the overall evaluation of service quality is still controversial [61]. Therefore, the interactions of expectations and perceptions independently may be considered without a predefined relationship between them. In this case, input layer of this neural network model consists of fifty-six nodes, twenty-eight input data for expectations and twenty-eight for perceptions. The training and testing of data are carried out in a similar fashion.

4.4.3 Performance of the Models

Each of the above models for a particular stakeholder is run varying learning parameter, momentum parameter and number of cycles till root mean square error (RMSE) is minimised. A model is said to perform best when percentage of correct outputs is higher for the same RMS value. The learning parameters lie between 0.07 and 0.1 whereas momentum parameter approaches to zero (0.01 to 0.03). The number of cycles varies from model to model for different stakeholders. The value ranges from 18680 to 293380 for students whereas it ranges from 3730 to 30855 for alumni. But for parents and recruiters, the training cycles ranges from 2760 to 7975. The RMS error ranges from 0.15 to 0.25 for students, alumni and parents whereas the range is from 0.07 to 0.08 for recruiters. Considering the maximum percentage of correct outputs with minimum RMS error, P-E gap model is found to be the best model for predicting correct output for all the stakeholders. The values of correct outputs for different stakeholders for P-E gap model are found to be 77%, 90%, 70% and 82% for students, alumni, parents and recruiters respectively. The parameters used in all four models are shown in Table 4.2.

Table 4.2: Results of Neural Network Models

Stakeholders	Neural Network models	Learning parameter	Momentum parameter	Number of cycles	RMS Error	Percentage of correct output
Students	P-E Gap	0.10	0.02	293380	0.21	77*
	P-only	0.09	0.03	18680	0.22	62
	E-P Gap	0.08	0.01	461380	0.25	69
	E & P	0.09	0.02	379195	0.21	69
Alumni	P-E Gap	0.07	0.01	21775	0.15	90*
	P-only	0.09	0.03	30855	0.15	60
	E-P Gap	0.08	0.01	17725	0.17	70
	E & P	0.10	0.03	3730	0.19	60
Parents	P-E Gap	0.08	0.02	4150	0.15	70*
	P-only	0.08	0.01	7975	0.17	70
	E-P Gap	0.09	0.03	6500	0.18	70
	E & P	0.10	0.02	3980	0.19	69
Recruiters	P-E Gap	0.09	0.03	7095	0.07	70*
	P-only	0.09	0.01	3350	0.08	70
	E-P Gap	0.09	0.03	7320	0.07	50
	E & P	0.09	0.03	2760	0.07	50

Note: * indicate the highest percentage of correct output

It may be concluded that P-E gap model performs best for predicting quality in an education set up considering the needs of most important stakeholders. This is exactly same as the result obtained by Parasuraman et al. using SERVQUAL applied to a wide range of service industries such as, retail banking, credit card, securities brokerage and product repair and the maintenance. But the use of perception and expectation gap concept of service measurement raises related analytical concerns about its low reliability, poor discriminant validity and spurious correlations [5,169,170]. Therefore, Cronin and Taylor proposed the perception-only model which is claimed to perform better on various validity criteria when tested in the service sectors such as banking, pest control, dry cleaning, and fast food, and improves prediction power of the model [5]. However, greater variability of SERVQUAL scores across the various dimensions increases its diagnostic power and provides for a better method of identifying areas of deficiency in service quality in service organizations. Therefore, Parasuraman et al. suggest the need for a trade-off

between predictive power and diagnostic value of the two methods of service quality measurement [56,57]. Assuming customers enter a service situation with some expectations derived through previous experiences of similar service or generated by the customers independently, Ravi et al. proposed to measure quality as the difference between expectation and perception or E-P gap [61,212]. A positive E-P score implies that customer expectations are not met. Customer expectations and perceptions are generally accepted as a part of the service experience. Therefore, the interaction of expectations and perceptions without predefined relationship between them can be considered as a model referred to the E&P model. Comparison of E-P model with other models in auto-dealership networks demonstrates that E-P gap model performs best. It is evident that performance of the model is highly application specific. As a matter of fact, the comparative study of four models suggests that P-E model has better predictive power for all the important stakeholders in a TES. The second best model is found to be E-P model for students and alumni whereas P-only model for parents and recruiters. This indicates that parents and recruiters do not overemphasize on expectations but judge the quality of education in an indirect way from their wards and job seekers. It is worthy to mention that E&P is the worst among all models for all stakeholders considered in this study. Since statistical evidence also favors 'EduQUAL', it may be used for predicting service quality in TES and identifying deficiency in the system according to four important stakeholders of the system. Sensitivity analysis of the best model will help to identify the deficiency in the system.

4.5 Sensitivity Analysis

In order to find the robustness of the proposed model, sensitivity analysis is carried out for the best models (P-E model). Sensitivity analysis is used to study the impact of changes in service performance along the various items (inputs) on customer evaluation of service quality (output). The inputs in the test samples are varied one at a time systematically up and down 10 percent (±10%) from its base value holding other items at their original values. The scaled

change in output is calculated with the current input increased by 10 per cent and the current input decreased by 10 per cent. The scaled change in output is given by:

$$scaled\ change\ in\ output = \frac{Scaled\ output\ for\ 10\%\ increase\ in\ input - scaled\ output\ for\ 10\%\ decrease\ in\ input}{2}$$

…….(4.3)

Thus, the results obtained are the scaled output change per ten percent change in input. The calculation is repeated for every input (P-E gap) and for every fact and then averaged across all the facts yielding a single mean scaled change in output for each input service criterion (Table 4.3).

Table 4.3: Sensitivity Analysis

Inputs	Students	Alumni	Parents	Recruiters
1. Training on state-of-the art technology.	-0.091	-0.154	-0.234	-0.065
2. Practical orientation in education.	-0.004	-0.032	+0.038	-0.030
3. Adaptability to modern techniques.	+0.123	+0.132	+0.042	-0.120
4. Design of course structure based on job requirements.	-0.214	+0.031	+0.208	+0.062
5. Problem solving skills.	-0.008	+0.066	+0.002	-0.185
6. Sense of social obligation	+0.033	-0.023	+0.109	+0.104
7. Prompt service at service departments.	+0.062	-0.009	-0.123	+0.007
8. Courteousness and willing to help.	-0.088	-0.112	-0.028	+0.004
9. Cleanliness, orderliness, systematic and methodical.	-0.135	-0.063	-0.133	+0.018
10. Transparency of official procedure, norms and rules.	+0.240	+0.024	-0.081	+0.068
11. Adequate facilities/infrastructure to render service	+0.032	+0.002	+0.240	+0.031
12. Well equipped laboratories with modern facilities.	-0.300	-0.009	+0.039	+0.060
13. Comprehensive learning resources.	-0.009	-0.075	-0.004	-0.033
14. Academic, residential and recreational facilities.	-0.032	+0.046	-0.079	+0.090

15. Aesthetic views of facilities.	+0.026	+0.027	+0.139	+0.041
16. Training in a well equipped communication laboratory	+0.070	-0.088	+0.189	-0.026
17. Opportunities for campus training and placement	-0.089	-0.062	-0.075	-0.070
18. Effective classroom management	+0.065	+0.003	-0.244	-0.077
19. Encouragement for sports, games and cultural activities	-0.140	-0.290	+0.087	-0.009
20. Enhancement of knowledge	+0.020	+0.087	+0.078	-0.074
21. Adherence to schedule	+0.088	+0.106	-0.056	+0.160
22. Extra academic activities	+0.556	+0.042	+0.091	+0.029
23. Recognition of the students	-0.030	-0.026	-0.179	+0.088
24. Adequacy of subject teachers	+0.551	+0.031	+0.031	+0.008
25. Available regularly for students' consultation	-0.331	+0.052	-0.124	-0.099
26. Close supervision of students work	-0.023	-0.028	-0.151	-0.060
27. Expertise in subjects and well organized lectures	-0.045	-0.185	-0.144	-0.087
28. Good communication skill of academic staff	-0.226	-0.068	-0.115	-0.113

Note: The negative score for average scaled change in output scores per 10 percent variation in inputs is the norm. Percentage of negative score for various stakeholders: Students - 57%; Alumni - 53%; Parents -53%; Recruiters - 50%.

Increasing input (gap) from its base value causes decrease in service quality due to the widening of the gap whereas reduction of gap indicates an increased service quality evaluation. Logically, net effect of change in input (gap) results in negative score for average scaled change in output. About 50 to 60 percent of input items produce negative service quality changes as expected. The percentages of items produce negative scores are 57%, 53%, 53%, and 50% for students, alumni, parents and recruiters respectively. However, positive or increased service quality is also obtained in all cases. This irregularity may be attributed to existence of noise in the survey data. Noisy data exists when customer responding to survey having similar evaluation on individual question but different evaluation of the overall service quality. The values of scaled change in output for items having negative scores for each stakeholder are

arranged in an ascending order and shown in Tables 4.3.1, 4.3.2, 4.3.3 and 4.3.4.

Table 4.3.1: Students' Priority for Improvements

Inputs	Mean Effects
Available regularly for students' consultation(Item 25)	-0.331
Well equipped laboratories with modern facilities (Item 12).	-0.300
Good communication skill of academic staff (Item 28)	-0.226
Design of course structure based on job requirements(Item4)	-0.214
Encouragement for sports, games and cultural activities(Item 19)	-0.140
Cleanliness, orderliness, systematic and methodical (Item 9).	-0.135
Training on state-of-the art technology (Item 1)	-0.091
Opportunities for campus training and placement(Item 17)	-0.089
Courteousness and willing to help (Item 8).	-0.088
Expertise in subjects and well organized lectures(Item 27)	-0.045
Academic, residential and recreational facilities (Item 14).	-0.032
Recognition of the students(Item 23)	-0.030
Close supervision of students work(Item 26)	-0.023
Comprehensive learning resources (Item 13).	-0.009
Problem solving skills (Item 5).	-0.008
Practical orientation in education (Item 2)	-0.004

Table 4.3.2: Alumni's Priority for Improvements

Inputs	Mean Effects
Encouragement for sports, games and cultural activities(Item19)	-0.290
Expertise in subjects and well organized lectures(Item 27)	-0.185
Training on state-of-the art technology (Item 1)	-0.154
Courteousness and willing to help (Item 8).	-0.112
Training in a well equipped communication laboratory(Item 16)	-0.088
Comprehensive learning resources (Item 13).	-0.075
Good communication skill of academic staff (Item 28)	-0.068
Cleanliness, orderliness, systematic and methodical (Item 9).	-0.063
Opportunities for campus training and placement(Item 17)	-0.062
Practical orientation in education (Item 2)	-0.032
Close supervision of students work(Item 26)	-0.028
Recognition of the students(Item 23)	-0.026
Sense of social obligation(Item 6)	-0.023
Prompt service at service departments (Item 7).	-0.009
Well equipped laboratories with modern facilities (Item 12).	-0.009

Table 4.3.3: Parents' Priority for Improvements

Inputs	Mean Effects
Effective classroom management(Item 18)	-0.244
Training on state-of-the art technology (Item 1)	-0.234
Recognition of the students(Item 23)	-0.179
Close supervision of students work(Item 26)	-0.151
Expertise in subjects and well organized lectures(Item 27)	-0.144
Cleanliness, orderliness, systematic and methodical (Item 9).	-0.133
Available regularly for students' consultation(Item 25)	-0.124
Prompt service at service departments (Item 7).	-0.123
Good communication skill of academic staff (Item 28)	-0.115
Transparency of official procedure, norms and rules (Item 10).	-0.081
Academic, residential and recreational facilities (Item 14).	-0.079
Opportunities for campus training and placement(Item 17)	-0.075
Adherence to schedule(Item 21)	-0.056
Courteousness and willing to help (Item 8).	-0.028
Comprehensive learning resources (Item 13).	-0.004

Table 4.3.4: Recruiters' Priority for Improvements

Inputs	Mean Effects
Problem solving skills (Item 5).	-0.185
Adaptability to modern techniques (Item 3).	-0.120
Good communication skill of academic staff (Item 28)	-0.113
Available regularly for students' consultation(Item 25)	-0.099
Expertise in subjects and well organized lectures(Item 27)	-0.087
Effective classroom management(Item 18)	-0.077
Enhancement of knowledge(Item 20)	-0.074
Opportunities for campus training and placement(Item 17)	-0.070
Training on state-of-the art technology (Item 1)	-0.065
Close supervision of students work(Item 26)	-0.060
Comprehensive learning resources (Item 13).	-0.033
Practical orientation in education (Item 2)	-0.030
Training in a well equipped communication laboratory(Item16)	-0.026
Encouragement for sports, games and cultural activities(Item19)	-0.009

The larger negative mean effect value indicates a large change in the overall evaluation of service quality (outputs) with the same percentage change in gaps (inputs). Therefore, the items resulting large negative mean effect are treated as deficient items where improvements are needed. From Table 4.3.1, it is evident that students suggest improvements (considering a threshold value of

evaluation scores less than -0.1) on item 25 (Available regularly for students' consultation), item 12 (Well equipped laboratories with modern facilities), item 28 (Good communication skill of academic staff), item 4 (Design of course structure based on job requirements), item 19 (Encouragement for sports, games and cultural activities) and item 9 (Cleanliness, orderliness, systematic and methodical). Alumni cite item 19 (Encouragement for sports, games and cultural activities), item 27 (Expertise in subjects and well organized lectures), item 1 (Training on state-of-the art technology) and item 8 (Courteousness and willing to help) as the most important quality factors that need to be improved as shown in Table 4.3.2 using a threshold value of -0.1. However, parents propose nine out of fifteen items having score more than -0.1 (Table 4.3.3). These are listed as items 18 (Effective classroom management), item 1 (training on state-of-the art technology), item 23 (Recognition of the students), item 26 (close supervision of students work), item 27 (expertise in subjects and well organized lectures), item 9 (Cleanliness, orderliness, systematic and methodical), item 25 (Available regularly for students' consultation), item 7 (Prompt service at service departments) and item 28 (good communication skill of academic staff). The parents seem to be suggesting ambitious improvement plans to provide quality education in a TES. Similarly, the recruiters indicate that service items such as item 5 (Problem solving skills), item 3 (Adaptability to modern techniques) and item 28 (good communication skill of academic staff) badly need improvement (Table 4.3.4).

It can be observed from Tables 4.3.1, 4.3.2, 4.3.3 and 4.3.4 that there are six common items rated negative score by all stakeholders. The six common items include training on state-of-the art technology (item 1), comprehensive learning resources (item 13), opportunities for campus training and placement (item 17), close supervision of students work (item 26), expertise in subjects and well organized lectures (item 27) and good communication skill of academic staff (item 28) as shown in the Figure 4.3. It implies that these six items have strong effect on service quality and the policy makers of the TES must focus on these areas for improving satisfaction level of potential stakeholders. It may be

concluded that the neural network developed in this study to model education quality are adequate for predicting the overall evaluation of the technical education system by their stakeholders but not robust enough for sensitivity analysis indicating a need for future research.

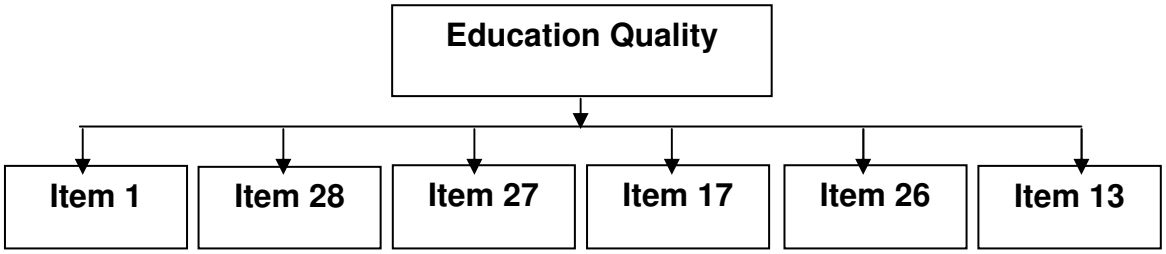


Figure 4.4: Uniform construct of education quality

4.6 Conclusions

The major contribution of this study is to provide a systematic integrated approach for modeling customer evaluation of service quality applied to technical education. As the quality of service largely related to the human behavior, the quality dimensions and items under each dimension of the measuring instrument widely differ depending on application to the type of service settings. Most of the service sectors deal with a single customer base and customer satisfaction is of prime importance for them. However, the stakeholders in an educational setting range from students to recruiters with varying level of interaction with the system and expectations from the system. An educational set up must satisfy the needs of such a wide range of stakeholders. This results in difficulties for implementing quality control and improvement programmes and policy planning. To this end, 'EduQUAL', a survey-based model has been developed in chapter 3 specially to suit a technical education system. The survey data are tested for reliability by finding out Chronbach Alpha and validated using factor analysis followed by varimax rotation. Factor analysis makes it possible to define the five dimensions of the instrument and lists out quality items conforming to the need of four types of stakeholders.

As artificial neural networks are capable of simulating human evaluation process adequately, four neural network models such as P-E gap, P-only, E-P gap and E&P models are developed. The responses obtained from stockholders for the individual service items serve as inputs to the different neural network models. It has been observed that P-E gap model is the best model for predicting the service quality for all stakeholders considered in this study. The study reconfirms that traditional P-E gap for defining quality outperforms other gap models. The second best model for students and alumni happens to be E-P gap model. It implies that expectations do and should play a role in the measurement of service quality. However, our study suggests that E&P model should be used cautiously for predicting quality, as its performance is not satisfactory as far as education quality study is concerned. The second best model for parents and recruiters is P-only model implying that even if they have expectations but it does not significantly affect their evaluation process. The reason is being that the expectations are derived in an indirect way through word-of-mouth or some other sources without having any direct service experience.

The final step in our study demonstrates the use of sensitivity analysis of the best model to identify the deficient items suggested by all four stakeholders for providing guidelines to the policy makers. The areas where the improvements in the service is required for a technical education system (TES) in the context of this study are training on state-of-the art technology (item 1), comprehensive learning resources (item 13), opportunities for campus training and placement (item 17), close supervision of students work (item 26), expertise in subjects and well organised lectures (item 27) and good communication skill of academic staff (item 28). The present technical education system throughout the country urgently needs to modernize the syllabi and course curriculum keeping in view of rapid technological growth. Mostly, the institutions suffer from shortage of learning resources like books, journals, software and training modules causing serious impediments for independent growth of the students. The locational disadvantage and lack of industry-institute interaction squeezes job opportunity of the students. As far as teaching staffs are concerned, vacancies exist in large

number of institutions due to difficulties in getting right faculty. Moreover, it is also difficult to retain the existing faculties because they are not motivated properly for instilling pride of their profession in them.

Although this study demonstrates the methodology for modeling customer evaluation of service quality in education sector at an aggregate level, the approach is quite general and can be applied to any specific organisation. However, we recommend identification of customers at the first step and then meticulously finding out their requirements. The next step is to design a measuring instrument for particular application and should be used only after validating through statistical tests. In the third step, appropriate neural network model may be developed and sensitivity analysis of the model to carried out for identification of current deficient items. The neural network models developed in this study are adequate for predicting the evaluation of customers. However, sensitivity analysis of neural network models indicates that the models are not robust enough. Therefore, future research in this direction may be carried out.

CHAPTER V

Framework for System Design Requirement

5.1 Introduction

Manufacturing and service companies must seek higher levels of quality through adoption of continuous improvement strategies to meet the challenges of global competition. Therefore, need arises for design of product or service through adequate planning process. As quality of education is perceived differently by its important stakeholders such as students, alumni, parents, recruiters, faculties, supporting staff, government, society and administrators, the administrators of education face difficulties in setting up the norms or policies that suit all the stakeholders. Therefore, it is of prime importance for administrators of TES to prioritize the system design approaches that bears in its ability to satisfy the customers. To address the issues the administrators must identify the quality items that need improvements through exhaustive analysis of pertinent data related to quality items. Most of the important stakeholders of TES have already identified six numbers of common items of quality that need improvement as discussed in chapter 4. In order to meet the requirements of these items, service system must be designed. For designing of service system, Quality Function Deployment (QFD) has been employed because QFD is the best way of converting customer's voice into engineering characteristics. It is considered as a powerful quality tool because it can incorporate the voice of the customer in the design phase itself so that the final product will be well designed to satisfy the customer's needs. In addition, it provides an insight into the complete design of product/service operation from concept to final product and improves the efficiency of the organization by eliminating problems at an early stage [213]. QFD can be used as a planning tool for both tangible products and intangible services including manufactured goods, service industry, software products, IT projects, business process development, government, healthcare, environmental initiatives, and many other applications.

5.2 Importance of Policy Planning for Quality Improvement

All the service sectors are associated with the major service quality characteristics such as intangibility, inseparability, variability and perishability.

Education sector, specifically TES represents, a service sector that satisfy all above stated characteristics. Education, in general, has a direct impact on society for its growth and socio-economic development. In India, the fact was realized quite early and impulse of creation of centers of technical training came long ago. Today, many engineering colleges and technical universities with different courses in undergraduate, postgraduate and research levels are in existence and compete with each other as well as with the foreign institutes for imparting quality education. All India Council of Technical Education (AICTE) registers 1,346 numbers of engineering colleges in different parts of the country with an intake capacity of 43,9,689 in different branches of engineering and technology till 2004 (Table 5.1). Limited number of state funded institutions and diminishing funding in higher education by government caused mushrooming of private institutions in India. Therefore, the students have wide option to choose the institution to pursue their interests. As the students bear the complete expenditure of education, they deserve the best education. Therefore, quality has become a competitive weapon for the institutions to serve and retain their primary customers (students).

Table 5.1: Number of Technical Institutions in India (Source: AICTE)

Region	State/Union Territory	ENGINEERING	
		No. of Institutions	Intake Capacity
Central	1. Madhya Pradesh	61	20210
	2. Chhattisgarh	14	4020
	3. Gujarat	37	12965
	Total	**112**	**37195**
Eastern	1. Mizoram	1	120
	2. Sikkim	1	525
	3. West Bengal	54	15477
	4. Tripura	1	180
	5. Meghalaya	1	240
	6. Arunachal Pradesh	1	210
	7. Andaman&Nicobar	-	-
	8. Assam	3	750
	9. Manipur	1	115
	10. Nagaland	-	-
	11. Orissa	41	13014

	12. Jharkhand	10	3385
	Total	**114**	**34016**
North	1. Bihar	8	1905
	2. Uttar Pradesh	89	28953
	3. Uttranchal	9	1440
	Total	**106**	**32298**
North-West	1. Chandigarh	5	800
	2. Haryana	38	12785
	3. Himachal Pradesh	5	1260
	4. Jammu& Kashmir	5	1545
	5. New Delhi	14	4330
	6. Punjab	45	14880
	7. Rajasthan	41	15045
	Total	**153**	**50645**
South	1. Andhra Pradesh	236	82970
	2. Pondicherry	6	2370
	3. Tamil Nadu	254	80417
	Total	**496**	**165757**
South-West	1. Karnataka	118	46375
	2. Kerala	89	24413
	Total	**207**	**70788**
West	1. Maharashtra	155	48250
	2. Goa	3	740
	3.Daman & D,Dadar,N.H.	-	**-**
	Total	**158**	**48990**
	Grand Total	**1346**	**439689**

In chapter 4, it has been shown that there are six numbers of common items of quality that are relevant to the four important stakeholders (students, alumni, parent and recruiters). They are ‘training on state-of-the art technology’, ‘comprehensive learning resources’, ‘opportunities for campus training and placement’, ‘close supervision of students work’, ‘expertise in subjects and well organized lectures’ and ‘good communication skill of academic staff’. In the opinion of stakeholders, these six items are deficient items in Indian TES and needs improvement for providing quality education. Hence, the policy makers must focus on these areas for improving the satisfaction level of potential stakeholders. In this regard, QFD enables the decision makers to identify system design requirements to cater to the needs of specified customer needs. The

administrators of TES may face difficulty in implementing all system design requirements at a time. Therefore, prioritization of them may be viable solution.

5.3 Quality Function Deployment (QFD) as a Planning Tool

QFD is a tool that has been successfully used to answer the voice of customer. The primary objective of QFD is to satisfy the customer at the very beginning i.e. the product design phase. It is basically employed to plan and design new or improved products/services. A cross-functional team is employed to determine customer needs and translate them into product designs through a structured and well-documented framework. It helps the companies to maintain their competitiveness by decreasing costs, increasing revenues, reducing the time to produce new products or services and minimizing the waste during the processes [213].

QFD was first conceptualized in the late 1960s [214]. In 1972, QFD was implemented successfully at the Kobe shipyards of Mitsubishi Heavy Industries Ltd. inspiring other industries to implement the technique throughout Japan. It remained a Japanese tool until the early 1980s. Following the article by Kogure and Akao and through Ford Motor Company and the Cambridge Corporation, QFD has entered the borders of the US and has started to play an important role at companies such as General Motors, Chrysler, Digital Equipment, Hewlett-Packard, AT&T, Procter and Gamble, and Baxter Healthcare [217-216]. There are two major organizations as sources of QFD viz., American Supplier Institute (ASI) and GOAL/QPC (a non-profit institution with the mission to help organizations and communities to grow and prosper since 1978) that developed their own models having many similarities to each other. The ASI employs a basic four-matrix method developed by Macabe, a Japanese reliability engineer, while GOAL/QPC uses a multiple matrix developed by Akao that incorporates many disciplines into a less structured format consisting of a matrix [217]. The technique of QFD is also extensively used in service sectors. Early applications of QFD in service organizations in Japan by Ohfuji, Noda and Ogino in 1981 were for a shopping mall, a sports complex, and variety retail store [218]. Kaneko

has been integrating QFD, reliability and quality circle activities in hotels, shopping centers and hospitals [92-94].

The QFD methodology begins with the accumulation of the voice of customer (customer requirements). To satisfy customers it is necessary to understand their requirements and how well these requirements affect the satisfaction level of the customer. The relationships between the customer requirements and their satisfaction have been explained in Kano's model of quality consisting of three types of customer requirements such as normal requirements, expected requirements and exciting requirements influence the satisfaction of the customers as depicted in Figure 5.1 [219].

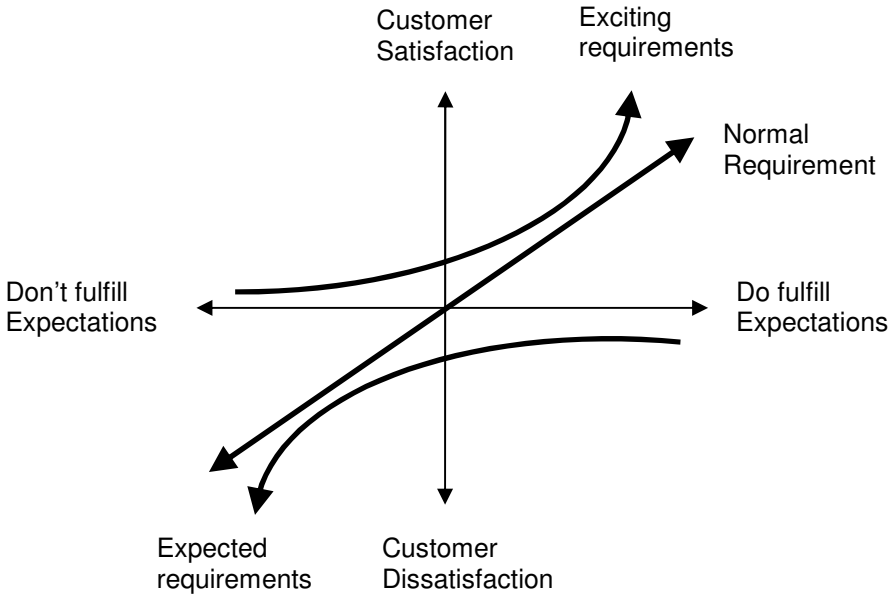


Figure 5.1: Kano's Model of Quality

The basic idea of QFD is to transform the above stated customer requirements into specific design requirements. QFD analysis starts by obtaining the customer requirements (CRi) with respect to the product being designed. These requirements are commonly referred to as the 'whats' and can be derived through the interview/questionnaire survey. Once the 'whats' are established, the QFD team then determines the mechanism that would satisfy the 'whats'. These mechanisms are commonly referred to as 'hows'. The 'hows' comprises the list of technical descriptions of the product from the customer perspective. The technical descriptions (TD_j) might be linked with other elements of the product life

cycle process including design activities (DA_j). Next, the QFD team establishes relationships between them. They assign a strength value of very weak, weak, moderate or strong to each relationship. Furthermore, the team will also assess each (TD_j) with respect to its interaction with the other (TD_j) to determine if there is positive, negative or no correlation. The product features are then related to themselves in the roof of the diagram using correlation symbols such as strong, moderate, weak and very weak. The strength values lie between 0 to 1. The QFD team incorporates all the information on a graphical display known as **'House of Quality'**. This house provides a framework that guides the team through the QFD process. It is a matrix that identifies the 'whats' and 'hows', the relationship between them and criteria for deciding which of the 'hows' will provide the greatest customer satisfaction. The peak of the house identifies the inter-relationships between the 'hows'. When the house of quality is complete, the QFD team can then analyze and use it to achieve a product/service realization that will allow the organization to enjoy greater customer and employee satisfaction, improved product/service performance and enhanced profitability [17]. Enhancements to the QFD process include adding importance measures to the customer requirements including target values for product design features and relating product design features to part and mechanism characteristics. Figure 5.2 shows a typical QFD matrix (house of quality) that is the foundation of QFD practices. The rows of the matrix in Figure 5.2 are the customer requirements i.e. what the customer wants in the product. The columns of the matrix show what the manufacturer does to ensure the quality of the product. The right side of the matrix contains the planning information i.e. the importance rating, competitive analysis, target value, amount of scaling up necessary and the sales points. The relationships between customer requirements and design requirements are categorized in the body of the matrix. The important goal of QFD is to turn the design requirements into the detailed design activities. A full implementation of the QFD concept allows the customer requirements (CR_i) to be cascaded down through the technical descriptions (TDj) and functional descriptions (FD_j) to design activities (DA_j) as illustrated in Figure 5.3.

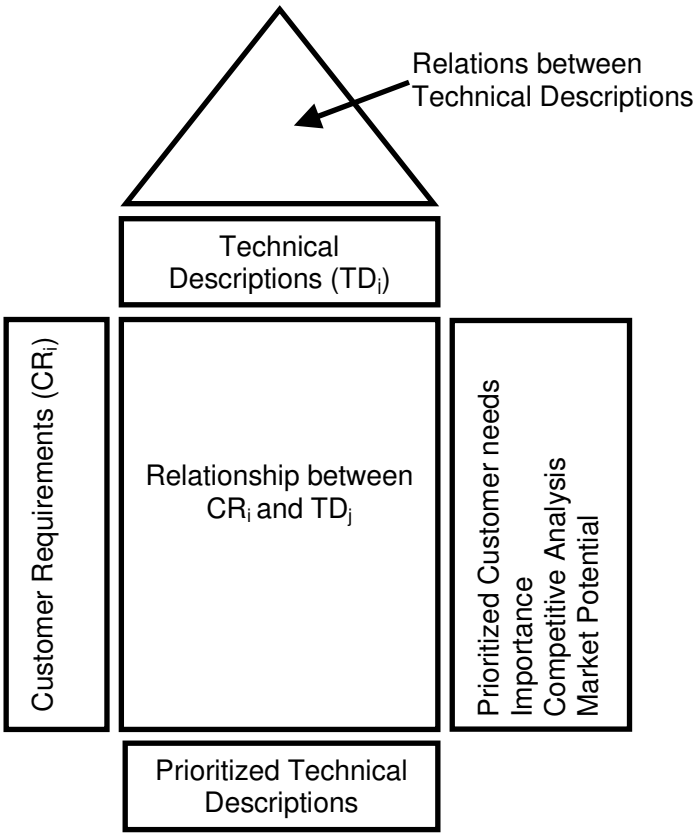


Figure 5.2: The House of Quality (QFD matrix)

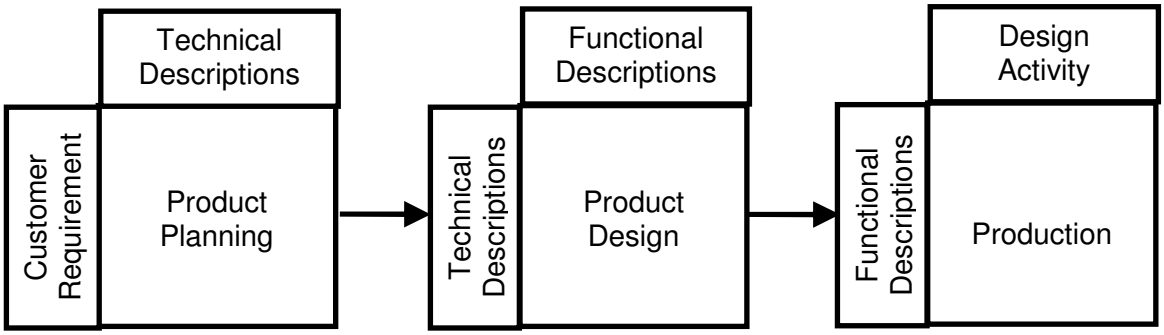


Figure 5.3: The Phases of QFD

5.4 Application of QFD in Education

QFD has been applied to university and other educational institutions in North America and Europe since late 1980s. One of the earliest uses of QFD in education was by Ermer at the Mechanical Engineering Department of the University of Wisconsin, Madison in 1991 where the department chairman used it to assess and respond to the needs of his faculty [98]. Application reports began appearing at the North American QFD Symposia in 1992 with a case study for a high school guidance program in which improvements in school planning activities were reported [96]. Krishnan and Houshmand demonstrated the use of QFD to balance between research and teaching at the University of Cincinnati, Department of Industrial Engineering [97]. In their study, various customers such as businesses and students were identified and their needs were translated through QFD into 'product features' such as 'communication skill' and 'practical knowledge' which were translated into 'process features' such as 'presentation, project reports and lab experiments. QFD was used by Lakeshore Technical College in Wisconsin to increase the variety of course offerings and other structural issues such as parking for its students [98]. Curriculum was addressed again in 1995 by Hillman and Plonka of Wayne State University that portrayed the strong relationship between the needs of industry and the employment of engineering graduates [99]. A full engineering update by Rosenkrantz led to an almost course-for-course match to Society of Manufacturing Engineers (SME) USA, curricula 2000 recommendations at the California state Polytechnic University [100]. A new application of QFD to strategic planning and funding was done at the University of Vermont by Hummel [101]. QFD principles are also extensively used during 1980s to improve European institutions. Clayton reported on the use of QFD to build a degree program in the Department of vision sciences at Aston University in the United Kingdom [102]. Nilsson et al. reported on the use of QFD to develop a Mechanical Engineering Program more responsive to the needs of changing industries in Sweden [103]. QFD was applied by Seow and Moody to design a M.Sc. degree in the UK [104]. Conjoint analysis has been recently employed in the market research area of QFD to

develop a TQM course curriculum [105]. In Japan, Akao, Nagai and Maki have systemized a process for identifying and analyzing both the internal and external evaluators of higher education and used QFD to identify and improve critical and conflicting needs [106]. In a survey, Tiede found out the perception of Australian high school educators about QFD after it was used to strengthen the understanding of school policies by students, parents and staff [107].

QFD is also frequently used in the Indian higher educational institutions. Mahapatra used the technique of QFD to find out the factors that need to be considered while formulating organization-wide policies [108]. Similar type of study was conducted where Analytic Hierarchy Process (AHP) had been combined with QFD to prioritize the stakeholder's requirements in a higher education system [17]. In another study, student's quality requirements of the educational system have been identified [8]. In this study, first of all the SERVQUAL methodology was applied to identify the gap and then QFD was applied to identify a set of design characteristics which can improve the quality of education in the education system. Though QFD has been extensively applied in the other countries, India has very little application of this tool in education. Therefore, in this research, it is decided to employ QFD technique to identify and prioritize the system design requirements in Indian technical institutions.

In chapter 4, it has been identified that there are six common items that is significant for the four important stakeholders of TES such as students, alumni, parents and recruiters. These common items need to be focused by the administrators to improve the quality of education. But most of the time the administrators face difficulty in implementing improvement program simultaneously to all customer needs at a time. Hence, there is a need to prioritize the customer requirements so as to enable the administrators to implement the policy of quality improvement in a phase manner. This can be achieved by adopting QFD method since it is frequently used in various decision-making problems due to its versatility [89,90].

In order to understand the customer needs and system design requirements, specific problems associated with imparting quality education and

policies need to be formulated to alleviate the identified limitations, a QFD team is formed in a reputed institute of Eastern India. The team consists of nine members representing major engineering branches, hall management and Student Activity Centre under the leadership of Dean (Academic Affairs). The team discussed about the system design requirements with reference to the six quality items and arrived at a decision that five design requirements can be referred to the said quality items. The various attributes for the five design requirements are shown in Table 5.2. Referring to Tables 4.3.1, 4.3.2, 4.3.3 and 4.3.4 in chapter 4, the six common items such as 'training on state-of-the art technology' (item 1), 'comprehensive learning resources' (item 13), 'opportunities for campus training and placement' (item 17), 'close supervision of students work' (item 26), 'expertise in subjects and well organized lectures' (item 27) and 'good communication skill of academic staff' (item 28) having negative scores are used as customer requirements. These items are ranked as per the stakeholders' actual response rate. The average of each item for all the stakeholders is taken as the overall ranking of the quality items. Considering the overall ranking of quality items the QFD team rate those items in a 1-10 scale, to be served as initial rating in the house of quality (Figure 5.4).

Table 5.2: System Design Requirements

Design Requirements	Attributes
1. Continuous evaluation system	a. Course credit system b. Performance monitoring through class tests, quizzes, assignments, mini projects, Examinations. c. Provision of time slots in academic curricula for counseling, advising and discussions. d. Timely evaluation of students' work in a fair and transparent manner. e. Exemplary punishment for academic indiscipline. f. Development of study materials and handouts.
2. Industry-institute interface	a. Industrial visits and training for students and faculties. b. Industrial consultancy and collaborative project works. c. Technology development and transfer.

3. Opportunities for knowledge up gradation	a. Attending and conducting seminars, conferences and workshops. b. Training for teachers including communication skill c. sufficient new addition of books, encyclopedia and journals. d. Fast and reliable IT services. e. Computational facilities, laboratory modernization, software. f. Continuing education and outreach activities.
4. Management responsibility	a. Instilling sense of pride and commitment through able leadership, participatory management and motivational measures. b. Funds mobilization c. Rewards and recognition for performers and guidance for non-performers. d. Fair, Transparent and uniform administrative norms and procedures conductive enough to retain faculties. e. Delegation of authority and responsibility.
5. Technology driven teaching aids	a. Modern visual instruments like OHPs, LCDs, Videos and Films in the class rooms. b. Prototypes, physical models, simulation and animated models. c. Virtual classroom facilities.

First of all the customer ratings for the customer needs are determined from the left correlation matrix of Figure 3 using the following formula;

$$Customer\ rating = Z_i + \left[\frac{1}{(n-1)}\right] \times \sum_{j \neq i}^{n} B_{ij} Z_j \tag{5.1}$$

where B_{ij} denote the relationship between customer needs i and j and Z_i is the initial customer ratings for customer need i. n is the number of customer needs.

The individual rating for each design requirement is obtained from the centre matrix using the following relation;

$$Design\ requirement = \left(\frac{1}{n}\right) \times \left[\sum_{j}^{n} A_{ij}\ X_j\right] \tag{5.2}$$

Where A_{ij} and X_j denote the relative importance of the ith characteristics with respect to the jth customer need in the relationship matrix and the importance of jth customer needs (customer ratings) and *n* is the number of customer needs.

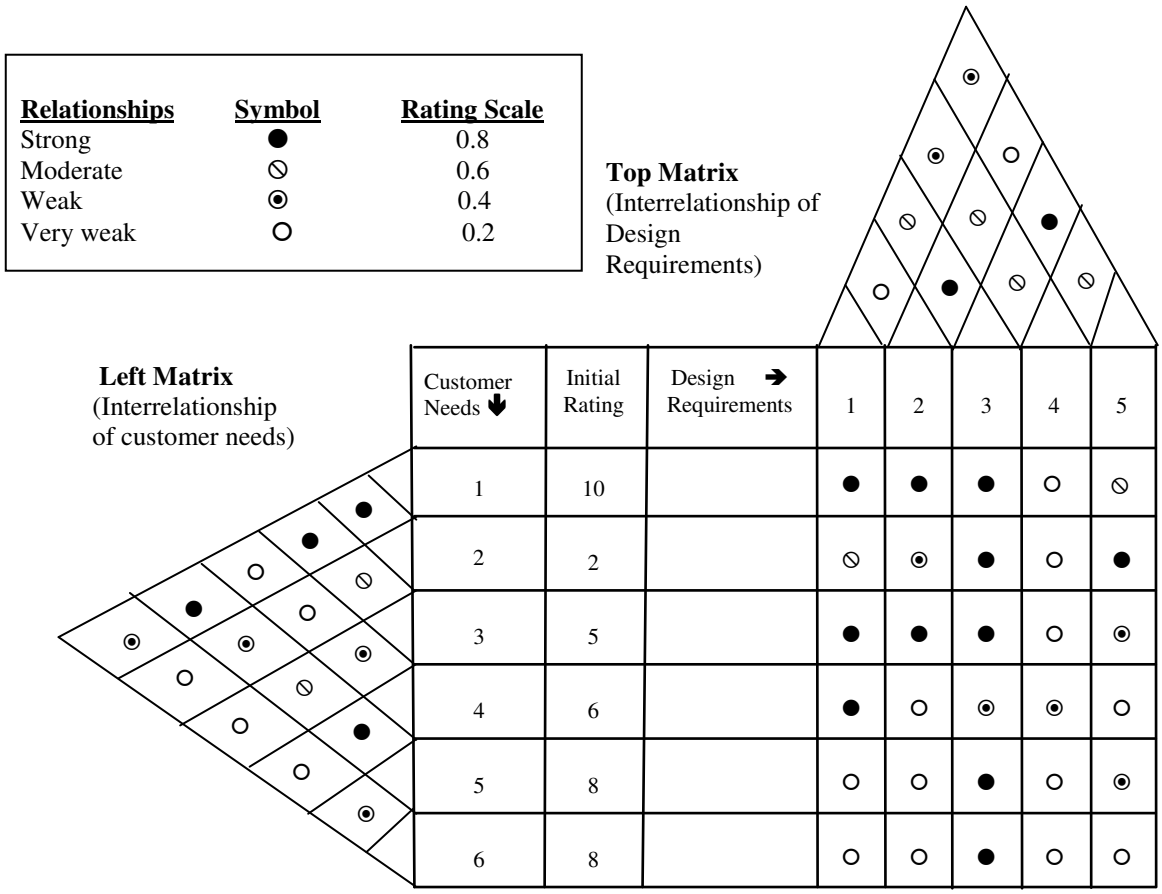


Figure 5.4: The House of Quality

The refined rating for each design requirement is calculated from the top matrix in a similar fashion as it is calculated for customer needs using equation (5.1). The final ratings of design requirements are normalized by dividing each rating with the maximum available ratings. The results are drawn using a program written in C^{++}.

Table 5.3: Ranking of Design Requirements

Design Requirements	Initial Ratings	Refined Ratings	Normalized Refined Ratings	Rank
1. Continuous evaluation system	5.29467	7.18147	0.73236	2
2. Industry-institute interface	4.26667	6.46493	0.65929	4
3. Opportunities for knowledge up gradation	7.02933	9.80593	1.00000	1
4. Management responsibility	2.18133	5.00660	0.51057	5
5. Technology driven teaching aids	4.00933	6.48520	0.66135	3

It is evident from Table 5.3 that the normalized refined ratings for the design requirements have maximum values in case of 'Opportunities of knowledge up gradation' followed by 'Continuous evaluation'. The 'Management responsibility' showed the lowest rating in this case. Therefore, the attributes listed under the 'Opportunities of knowledge up gradation' can be emphasized more in a priority basis by the administrators of a TES followed by the attributes of 'Continuous evaluation'. The various attributes under 'Opportunities of knowledge up gradation' are (1) attending and conducting seminars, conferences and workshops, (2) Training for teachers including communication skill, (3) sufficient new addition of books, encyclopedia and journals, (4) Fast and reliable IT services, (5) Computational facilities, laboratory modernization, software and (6) Continuing education and outreach activities. The other design requirements such as 'Industry-Institute Interface' and 'Technology driven teaching aids' can be taken up simultaneously in the next phase of the quality implementation program since both of them showed almost the same normalized rating. Although 'Management responsibility' has emerged as the least important design requirements but it's attributes such as (1) instilling sense of pride and commitment through able leadership, participatory management and motivational measures, (2) funds mobilization, (3) rewards and recognition for performers and guidance for non-performers, (4) fair, transparent and uniform administrative norms and procedures conductive enough to retain faculties, and (5) delegation of authority and responsibility are vital for system design in the overall implementation of the quality improvement program in a TES.

5.5 Conclusions

QFD technique has been used to improve the quality of products, processes and services since 1980s. Numerous applications of this technique in manufacturing as well as in the service sectors have been addressed. In education, QFD has been applied basically for curriculum development of the universities in the different parts of the world. It is also noted that the literature pertaining to the application of QFD in Indian education sector is scarce. This technique was also used in conjunction with other tools such as SERVQUAL, AHP, Fuzzy AHP and ANP to achieve better results.

In this chapter, a methodology for policy planning in TES using QFD has been proposed and illustrated through a case study. The common number of deficient items having negative scores as identified by four stakeholders of TES is used as customer needs. A QFD is formed to suggest design requirements to address the customer needs. These design requirements are incorporated in the house of quality against the customer needs. Initial ratings for customer needs are assigned as per the actual responses of the stakeholders in a 1-10 scale. Then the relationships between them are assigned weights between 0 to 1 (strong, moderate, weak and very weak). Similarly, the interrelationship between the design requirements and customer needs are established in the house of quality. Finally, it is found that the design requirements such as 'Opportunities of knowledge up gradation' may be given maximum weightage while designing the policy for a TES followed by the attributes of 'Continuous evaluation'.

CHAPTER VI

Benchmarking of Technical Institutions

6.1 Introduction

Among service sectors, TES is considered as an important one because it plays a pivotal role for socio-economic development of a country because it deals with knowledge development and dissemination, technology transfer, education and collaborative works with industries. Immense opportunities in technical education caused ever-increasing demand resulting in mushrooming growth in number of technical institutes especially in developing countries like India. Opening of offshore campus of foreign universities and diminishing public funding generated stiff competition for technical institute. Highly competitive environment makes quality as a key competitive weapon for attracting primary customers (students) in TES. Therefore, the challenges ahead of technical institutions necessitate reassessing the brand equity and market positioning through sufficient control to follow the quality standards of education [220]. The quality of education comprises various quality dimensions related to system level factors that enable quality education. Improvement upon these dimensions may lead an institution to become efficient one.

The conventional method adopted by various surveying agencies for assessing these institutes seems to be inadequate as it is based on summation of scores assigned to limited number of factors like infrastructure, number of students recruited by the recruiting firms and management styles. One of the major drawbacks of the conventional method is that it assigns equal weightage to all the factors considered. Further, the method lacks in reflecting the true picture on quality of education being imparted by an institution. For example, an institution having high score in “quality infrastructure” and low score in “quality faculty” may have the same overall quality with an institution having low score in ‘quality infrastructure’ and high score in the “quality faculty”. Intuitionally the later case should be treated as an efficient institution because profile of faculty plays a dominating role for imparting quality education in comparison to adequacy of infrastructure. Depending on sample size and criteria considered by surveying agencies, ranking of institutions vary from one agency to another. In order to alleviate such problem, quality dimensions defined in terms of expectations and

perceptions of the customers using instruments like ‘SERVQUAL’, ‘SERVPERF’ and ‘EduQUAL’ can be conveniently used to reveal complete picture of quality in an educational set up [2,4,221]. Technical institutions exhibit highly process oriented and a multi-stakeholder situation leading to difficulty in aggregating the functional variables (inputs and outputs) for the evaluation of education quality in order to improve the efficiency. Therefore, it is desirable to use a tool that is capable of relating customers’ perception (input) to the desired performance (output) of the TES and makes adoption of strategic decisions easier. Data Envelopment Analysis (DEA) is one such technique that aggregates the input and output components in order to obtain an overall performance measure through the comparison of a group of decision units. It evaluates performance of Decision Making Units (DMUs) by finding out the relative efficiency of the units under consideration. The DMUs can be business units (points of sales, bank branches, dealers and franchisees), government agencies, police departments, hospitals, educational institutions, and even assessment of human beings like athletic, sales and student performance. The major advantages of DEA are summarized as (i) it can handle multiple input and multiple output models, (ii) it does not require the functional relationship between inputs and outputs, (iii) it identifies the possible peers as the role models (benchmarks), (iv) it determines the possible sources of inefficiency and (v) it is independent of units of measurement of various parameters [226].

In this chapter, an attempt has been made to assess the efficiency of the institutes using various quality dimensions of education through application of Data Envelopment Analysis (DEA). The study seeks to measure the relative efficiency of twenty top graded technical institutions in India suggested by a leading Indian weekly magazine in association with a surveying agent [222]. In doing so, it is possible to measure the degree of variation in efficiency across the sector as a whole and to identify possible sources of inefficiency. The efficiency score has been calculated based on two scale of assumptions viz., CRS (Constant Return to Scale) and VRS (Variable return to scale). A comparison is

made between the ranking of the institutions based on the efficiency scores using CRS and VRS assumptions and the ranking of a leading surveying agent.

6.2 The Basics of DEA

As the efficiency is the key measure in DEA, it is required to emphasize on efficiency measure in the context of DEA. The efficiency can simply be defined as the ratio of output to the input.

$$Efficiency = \frac{Output}{Input} \tag{6.1}$$

The efficiency evaluation of a unit in presence of multiple inputs and outputs becomes difficult. The difficulties are further enhanced when the relationship between the inputs and outputs are complex and involve unknown tradeoff. Simple efficiency measure defined in equation (6.1) cannot be used in this situation. Therefore, efficiency score is calculated as the "weighted cost approach" in presence of multiple inputs and outputs as shown in equation (6.2).

$$Efficiency = \frac{weighted\ \ sum\ of\ \ outputs}{weighted\ \ sum\ of\ \ inputs} \tag{6.2}$$

The equation (6.2) can be mathematically expressed as

$$Efficiency = \frac{\sum_{r=1}^{n} u_r y_r}{\sum_{i=1}^{m} v_i x_i} \tag{6.3}$$

$Where;$ $y_r = quantity of\ output\ r$

$u_r = weight\ attached\ to\ output\ \ r$

$x_i = quantity\ \ of\ \ input\ \ i$

$v_i = weight\ \ attached\ \ to\ input\ \ i$

$r = 1, 2, ..., n = number\ \ of\ \ outputs$

$i = 1, 2, ..., m = number\ \ of\ \ inputs$

The major drawback with this measure is that it assumes that all weights are uniform. In order to alleviate this drawback, Farrell introduced a new measure of efficiency called 'technical efficiency' which employs the efficient production function [223]. To understand the concept of an efficient production function, we take the example of a set of firms employing two factors of production (inputs) to produce a single product (output) under conditions of constant returns to scale [224,225]. Considering the inputs and outputs for each firm an isoquant diagram is drawn as shown in Figure 6.1. A constant return to scale means that increase in the inputs by a certain proportion results in a proportional increase in the output. An isoquant diagram is the one in which all firms producing the same output lie in the same plane. A point represents each firm in an isoquant diagram so that a set of firms yields a scatter of points. An efficient production function is a curve that joins all the firms in an isoquant diagram utilizing the inputs most efficiently.

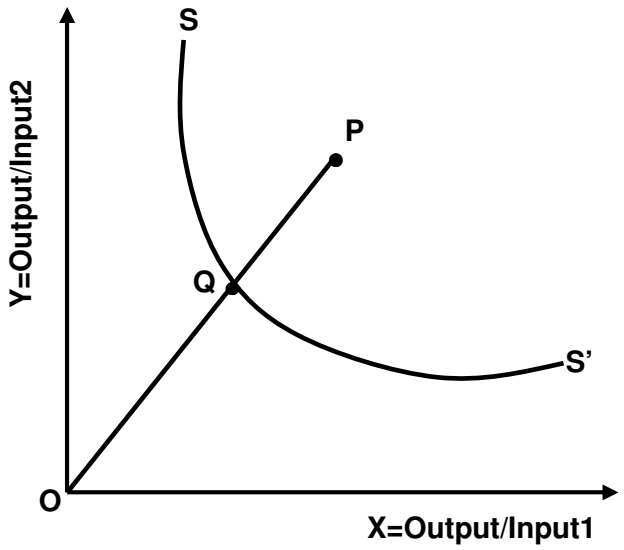


Figure 6.1: Representation of the Production Function

The point P represents an inefficient firm, as it is outside the isoquant SS'. It used two inputs per unit of output in a certain proportion. Since Q is on the isoquant curve, it represents an efficient firm producing same output as P but uses only a fraction of input (OQ/OP). This ratio is defined as the 'technical efficiency' of firm P. Similarly, the technical efficiency of firm Q is OQ/OQ=1,

which is an efficient firm. Adopting the idea from Farrell's technical efficiency that considers the relative performance of inputs and outputs, Charnes, et al. proposed a new methodology known as Data Envelopment Analysis (DEA) that can be used to measure the efficiency of a DMU relative to other DMUS in order to find the relative efficiency [226]. In DEA, the efficiency of any DMU is obtained as the maximum of a ratio of weighted output to weighted input subjected to the condition that similar ratios for every DMU be less that or equal to unity. Usually a vector of multiple inputs and multiple outputs characterizes the investigated DMUs. Thus, direct comparison of DMUs is generally difficult. In order to aggregate information about input and output quantities, DEA makes use of fractional and corresponding linear programmes (together with their duals) to measure the relative performance of DMUs [227,228]. In addition to calculating the relative efficiency scores, DEA also determines the level and amount of inefficiency for each of the inputs and outputs. The magnitude of inefficiency of the DMUs is determined by measuring the radial distance from the inefficient unit to the production function SS'. Algebraically the DEA model can be written as:

$$\max h_{j_0} = \frac{\sum_{r=1}^{n} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}}$$

$$subject\,to \sum_{r=1}^{n} u_r y_{rj_0} - \sum_{i=1}^{m} v_i x_{ij_0} \leq 0 \qquad (6.4)$$

$$u_r, v_i \geq 0 \; \forall r, i$$

where

h_{j_0} = *Relative efficiency of target DMU* j_0

r = number of output = 1, 2, ….., n

i = number of input = 1, 2, ……, m

j = number of DMUs = 1, 2, ..., s

The fractional program equation (6.4) can be reduced to Linear Programming Problem (LPP) as follows:

$$\max h_{j_0} = \sum_{r=1}^{n} u_r y_{rj_0}$$

$$subject\,to \sum_{i=1}^{m} v_i xij_0 = 1$$

$$\sum_{r=1}^{n} u_r y_{rj_0} - \sum_{i=1}^{m} v_i x_{ij_0} \leq 0 \tag{6.5}$$

$$u_r, v_i \geq 0 \;\forall\, r, i$$

The dual DEA model for the above LPP is used for benchmarking in DEA. For every inefficient DMU, DEA identifies a set of corresponding efficient units that can be utilized as benchmarks for improvement. The benchmarks can be obtained from the dual problem shown as equation (6.6) [229].

$$\min \theta$$

$$subject\ \ to \sum_{i=1}^{n} \lambda_i x_{ji} - \theta x_{jj_0} \leq 0 \;\forall\, j$$

$$\sum_{i=1}^{n} \lambda_i y_{rj} - y_{jj_0} \geq 0 \;\forall\, r \tag{6.6}$$

$$\lambda_i \geq 0 \;\forall\, i$$

where

θ = Efficiency Score

λ = Dual Variable

r = number of output = 1, 2, ….., n

i = number of input = 1, 2, ……, m

j = number of DMUs

The main difference between the primal (equation 6.5) and dual (equation 6.6) model of DEA is that the number of constraints of primal depends upon the

number of DMUs whereas in dual model the constraints depend upon the number of inputs and outputs.

The DEA models may have any of the two-orientation viz. input orientation or output orientation. Input orientation means how much inputs can be reduced while maintaining the same level of output. But output orientation of DEA is characterized by how much output can be increased while keeping the level of inputs constant. The latter orientation is more relevant for many service providers where the objective is to maximize the output maintaining the same level of inputs. Another variation to a DEA model is the returns to scale (RTS) assumption. Constant, decreasing, increasing, and variable returns to scale assumptions may be employed. Constant Return to Scale (CRS) implies that doubling inputs will exactly double outputs. Decreasing return to scale implies that doubling inputs will less-than-double outputs. Increasing return to scale implies that doubling inputs will more-than-double outputs. Thus, Variable Return to Scale (VRS) allows for a combination of constant, increasing, and decreasing inputs and outputs. The DEA model shown in equation (6.5) and (6.6) assumes a Constant Return to Scale (CRS). The drawback with the CRS model is that it compares DMUs only based on overall efficiency assuming constant returns to scale. It ignores the fact that different DMUs could be operating at different scales. To overcome this drawback, Banker, Charnes and Cooper developed a model which considers variable returns to scale and compares DMUs purely on the basis of technical efficiency [230]. The model can be shown as below.

$$\min \theta$$

$$\begin{aligned} subject\ \ to\ \ & \sum_{i=1}^{n} \lambda_i x_{ji} - \theta x_{jj_0} \leq 0\ \ \forall\ j \\ & \sum_{i=1}^{n} \lambda_i y_{rj} - y_{jj_0}\ \ \geq 0\ \ \forall\ r \\ & \lambda_i = 1\ \ \forall\ i \end{aligned} \tag{6.7}$$

The difference between the CRS model (equation 6.6) and the VRS model (equation 6.7) is that the λ_i is restricted to one. This has the effect of removing

the constraint in the CRS model that DMUs must be scale efficient. Consequently, the VRS model allows variable returns to scale and measures only technical efficiency for each DMU. Thus, a DMU to be considered as CRS efficient, it must be both scale and technical efficient. For a DMU to be considered VRS efficient, it only needs to be technically efficient.

6.3 Ranking of Technical Institutes: A DEA Approach

The literature review regarding the application of DEA in chapter 2 reveals that DEA has been extensively applied in education sector in order to find the efficiency and benchmarking of the institutions. However, benchmarking of institutions considering the satisfaction level of various stakeholders of education is found to be lacking. Since education sector, especially, TES is characterized by multiple stakeholders having different backgrounds and varied behavioral patterns, the expectations and perceptions of the stakeholders differs widely posing difficulties for the administrators for benchmarking of the institutions. Therefore, it is decided in this chapter to rank the technical institutions in India considering the expectations and perceptions of various stakeholders. As 'EduQUAL' has been successfully implemented in Indian context in order to evaluate the quality at aggregate level fitting to most important stakeholders, the service quality items indicated in 'EduQUAL' can be used in DEA for finding out the inefficient institutions which may be useful for policy making to improve the service quality in TES [38]. To this end, the ranking of technical institutions in India using DEA has been proposed considering the expectations and perceptions as the inputs and outputs respectively. It should be noted that non-linear functional relationship between expectations and perceptions has not been explored fully. In the absence of functional relation, linear relations may be assumed to model as per DEA paradigm so that some guidelines useful for the managers may be obtained. As DEA is a mathematical model that relates inputs and outputs to define an efficient frontier, qualitative terms expressed in quantitative form can be used as inputs and outputs. In order to apply DEA approach, the selected DMUs must possess the characteristics of homogeneity.

As a rule of thumb, the number of DMUs should be at least two to three times the sum of the number of input and output variables so that efficient DMUs can be discriminated efficiently. However, there are many instances in the literature where DEA has been used with small sample sizes because there is no mathematical relation exists between number of DMUs and model variables [231].

6.3.1 Procedure

Selection of DMUs

The quality of education plays a major role to gain an edge over its competitors and hence efficiency of an institution must relate its performance to quality dimensions. As quality in TES characterises multi-input and output system, its measurement through the efficiency score enables to provide not only an aggregate picture of performance of an institution in terms of quality education but also helps to re-assesses its brand positioning in market-place. The relative efficiency calculated for a number of institutions helps to rank them based on their efficiency score. The inefficient institutions can pursue continuous improvement strategies by adjusting the slack and target values. To address these issues, the objectives of present study focuses on finding out bench marking institutions, ranking of technical institutions of India based on their efficiency scores and discuss improvement areas for inefficient institutions. As DEA can handle multiple input and multiple output models and provides the improvement targets it can be a very useful tool for benchmarking of DMUs like the educational institutions where multi-stakeholder situation exists. Thus, a case study has been conducted to classify some of the technical institutions in India using DEA based on the responses of the stakeholders on 'EduQUAL' items.

In order to identify DMUs, twenty Indian institutions offering technical education in Undergraduate, Postgraduate, and Research level have been considered (Table 6.1). They happen to be top ranked institutions as per a survey conducted by a leading weekly magazine in India in association with a professional surveying agency [222]. The ranking is based on total score summed over perceptual score and factual score obtained from each DMU. The

perpetual score considers seven parameters such as reputation of the institute, curriculum, quality of academic input, student-care, admission procedure, infrastructure and job prospects whereas factual score is collected on three parameters like infrastructure, placements and faculty. In order to calculate the total score of an institute, seventy percent weightage is assigned to perceptual score and factual score carries thirty percent weightage.

Table 6.1: Selected Technical Institutions in India (DMUs)

DMUs	Name of the Institute	DMUs	Name of the Institute
1	Birla Institute of Technology, Ranchi	**11**	Indian Institute of Technology, Roorkee
2	College of Engineering, Guindy	**12**	Indian Institute of Technology, Guwahati
3	Delhi College of Engineering, Delhi	**13**	Institute of Technology, BHU
4	Dr. B.R. Ambedkar NIT, Jalandhar	**14**	Motilal Nehru NIT, Allahabad
5	Guru Nanak Dev College, Ludhiana	**15**	National Institute of Technology, Karnataka, Surathkal
6	Indian Institute of Technology, Chennai	**16**	National Institute of Technology, Thiruchirapally
7	Indian Institute of Technology, Delhi	**17**	National Institute of Technology, Warangal
8	Indian Institute of Technology, Kanpur	**18**	PIET's College of Engineering, Pune
9	Indian Institute of Technology, Kharagpur	**19**	Thapar Institute of Engineering and Technology, Patiala
10	Indian Institute of Technology, Mumbai	**20**	University Visvesvaraya College of Engineering, Bangalore

Questionnaire Survey

Data from twenty technical institutions (DMUs) are collected on twenty eight 'EduQUAL' items. The 'EduQUAL' items utilized for questionnaire survey are shown in Appendix 6.1. The responses of the stakeholders such as students, alumni, parents and recruiters for their perceptions and expectations under each item are collected. Each respondent is asked to rate his/her opinion in a Likert type scale 1 to 7 (1 being strongly disagree and 7 being strongly agree). The survey is administered to the respondents via e-mail, postal mode and personal contacts. Further, additional data are collected from the experts such as head of

institutions, head of departments/centres and deans of twenty DMUs through e-mail. The survey was conducted during June-August 2006. Responses from own institution are excluded from the data to minimise bias. Finally 512 responses are taken into consideration for further analysis after screening the responses for correctness and rationality in judgmental scores. The responses for each institute on every service items are aggregated to get a single value both for expectations and perceptions. The expectations of the stakeholders and experts in 'EduQUAL' items are considered as the inputs and perception scores are assumed as the outputs for Data Envelopment Analysis. Thus, we have twenty-eight inputs, twenty-eight outputs and twenty DMUs.

The DEA Model for TES

For ranking of technical institutions, the following parameters and variables are considered in the DEA model.

$h = relative\ efficiency$

$j = Number\ of\ DMUs = 20$

$r = Number\ of\ outputs = 28$

$i = Number\ of\ inputs = 28$

$y_{rj} = quantity\ of\ r^{th}\ output\ of\ j^{th}\ DMU$

$x_{ij} = quantity\ of\ i^{th}\ output\ of\ j^{th}\ DMU$

$u_r = weight\ of\ r^{th}\ output$

$v_i = weight\ of\ i^{th}\ input$

Pictorially, the DEA model for TES can be presented as shown in Figure 6.2.

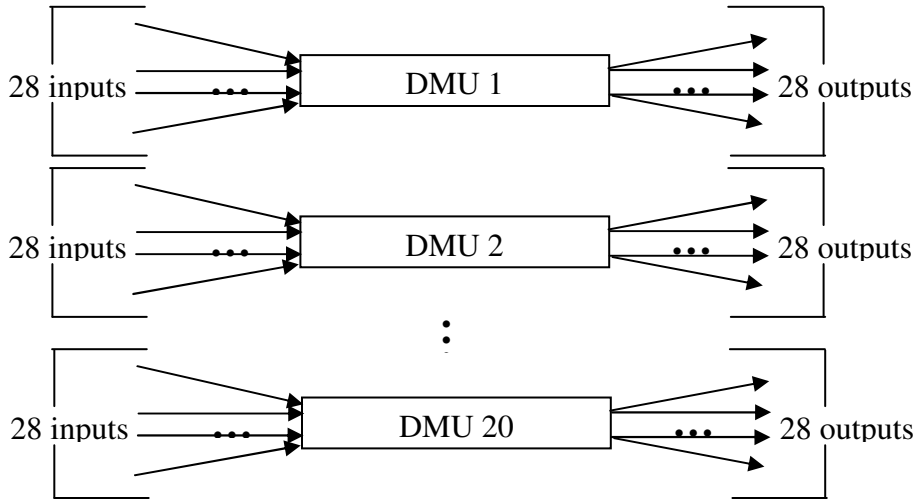


Figure 6.2: DEA Model for TES

The relative efficiency of a target DMU (j_0) is given by maximizing the efficiency of DMU j_0, subject to the efficiency (output/input) of all units being ≤ 1.

or, output – input ≤ 0

Algebraically, the model can be written as,

$$\max h_{j_0} = \frac{\sum_{r=1}^{28} u_r y_{rj_0}}{\sum_{i=1}^{28} v_i x_{ij_0}}$$

$$subject\,to \sum_{r=1}^{28} u_r y_{rj_0} - \sum_{i=1}^{28} v_i x_{ij_0} \le 0 \;\; j=1,2,...,20 \qquad (6.8)$$

$$u_r, v_i \ge 0 \;\forall r,i$$

The fractional program in equation (6.8) can be reduced to Linear Programming Problem (LPP) as follows:

$$\max \; h_{j_0} = \sum_{r=1}^{28} u_r \; y_{rj_0}$$

$$subject \;\; to \;\; \sum_{i=1}^{28} v_i \; x_{ij_0} \; = 1$$

$$\sum_{r=1}^{28} u_r \; y_{rj} \; - \sum_{i=1}^{28} v_i \; x_{ij} \; \le 0, \;\; j \; = 1, 2, ..., 20 \qquad (6.9)$$

$$u_r \; , \; v_i \; \ge 0 \; \forall \; r, i$$

The variables of the above problem are the weights and the solution produces the weights most favorable to unit j_0 and also produces a measure of efficiency. The decision variables $u = (u_1, u_2, ..., u_r, ..., u_{28})$ and $v = (v_1, v_2, ..., v_i, ..., v_{28})$ are respectively the weights given to the twenty-eight outputs and to the twenty eight inputs. The numerator of the objective function in equation (6.8) is the weighted sum of the output and the denominator is the weighted sum

of input for j_0 DMU respectively. In the constraint part we write the difference of weighted sum of outputs and weighted sum of inputs one by one for all the 20 DMUs. To obtain the relative efficiencies of all the units, the model is solved 20 times for one unit at a time.

6.3.2 Discussions

6.3.2.1 DEA with CRS Scale Assumption

The objective function for DEA has been fixed as the ratio of weighted sum of perceptions to the weighted sum of expectations assuming that perception of a stakeholder seldom touches the expectation. Hence, a DMU becomes a benchmark unit when the objective function becomes unity. In other words, perceptions equals to expectations. The general output oriented maximization CCR-DEA model is used to obtain efficiency score. **DEAP version 2.1** (Data Envelopment Analysis Programme) has been used to solve the model. The results of DEA are shown in Table 6.2.

The first column of the Table 6.2 represents the selected technical institutions (DMUs) arranged serially in alphabetical order. The second column specifies the efficiency score of the corresponding DMUs. The third column stands for the ranking by the surveying agency. Based on the efficiency score, DMUs are ranked as shown in the fourth column. The fifth column indicates the difference between the rank assigned by the surveying agency and the rank obtained through DEA. The sixth column shows the peers or the benchmarking units for the corresponding DMU. The seventh column indicates the weightage of each of the peers or the benchmarking unit. The last column shows the peer count of the DMUs, i.e. the number of times a particular DMU is being referred by other DMUs for improvements.

DEA efficiency ranking finds that eight DMUs out of twenty DMUs have emerged as benchmarking units for the other twelve DMUs. The benchmarking units are listed as DMU_6, DMU_7, DMU_8, DMU_9, DMU_{10}, DMU_{11}, DMU_{12} and DMU_{13} as shown in Table 6.2. The efficiency score for these DMUs approaches unity while that of DEA-inefficient DMUs is less than unity. The inefficient units

can refer the units given in column 6 with the corresponding weightage given in column 7 for improvement in education quality. For example, DMU_1 having efficiency score of 0.900 can refer DMU_6 and DMU_{12}. DMU_1 can assign a weightage of 0.669 to DMU_6 and 0.222 to DMU_{12} to become a benchmark unit. As shown in column 6, there are four DMUs (DMU_4, DMU_{16}, DMU_{18}, and DMU_{20}) which can refer different DEA-efficient (benchmark) units with varying degree of weightages. DMU_{14}, DMU_{15}, DMU_{17} and DMU_{19} consult three benchmarking units whereas DMU_1, DMU_2 and DMU_3 cite only two efficient institutes with the corresponding weightages. It is interesting to note that DMU_5 has only one reference institute (DMU_7) with a weightage of 1.138. Four DMUs (e.g. DMU_6, DMU_7, DMU_9 and DMU_{12}) have become the peer units seven times while DMU_8 and DMU_{13} become the referring institute for three and four times respectively. Six institutes ranked as 1 to 6 by surveying agency have become efficient units in DEA also. DMU_{12} and DMU_{13} have been ranked at 11th and 9th position respectively by the surveying agency but DEA treats them as efficient peer institutes. DMU_7 and DMU_8 are ranked as 1 and 2 position respectively by surveying agency and DEA treats them as most efficient units because the inefficient units refer these units most frequently. It can be observed from column 5 of Table 6.2 that major gainers in upgrading ranking position are DMU_{14}, DMU_{12} and DMU_1 whereas the major losers in respect to sliding of their position are DMU_3 and DMU_{18}. However, there is a scope for improvement of the technical institutions in India because mean efficiency score for all DMUs shows 0.934.

Table 6.2: Results of Data Envelopment Analysis (CRS model)

DMUs (Technical Institutions)	Efficiency	Ranking by surveying agency (a)	Ranking by DEA (b)	Difference (a-b)	Referring Institutes	Peer Weights	Peer Count
DMU_1	0.900	17	8	9	6 12	0.669 0.222	0
DMU_2	0.913	12	6	6	7 6	0.462 0.467	0
DMU_3	0.951	7	3	4	13 19	0.263 0.676	0
DMU_4	0.811	18	12	6	7 9 12 6	0.245 0.537 0.137 0.027	0
DMU_5	0.759	19	13	6	7	1.138	0
DMU_6	1.000	5	1	4	6	1.000	7
DMU_7	1.000	1	1	0	7	1.000	7
DMU_8	1.000	2	1	1	8	1.000	3
DMU_9	1.000	4	1	3	9	1.000	7
DMU_{10}	1.000	3	1	2	12	1.000	0
DMU_{11}	1.000	6	1	5	18	1.000	0
DMU_{12}	1.000	11	1	10	12	1.000	7
DMU_{13}	1.000	9	1	8	13	1.000	4
DMU_{14}	0.889	20	9	11	8 9 12	0.229 0.409 0.308	0
DMU_{15}	0.954	8	2	6	6 7 12	0.027 0.476 0.393	0
DMU_{16}	0.904	13	7	6	6 7 9 12	0.030 0.519 0.012 0.345	0
DMU_{17}	0.939	10	4	6	6 13 12	0.418 0.399 0.099	0
DMU_{18}	0.851	15	11	4	7 9 8 13	0.516 0.203 0.239 0.043	0
DMU_{19}	0.923	14	5	9	7 8 9	0.566 0.164 0.163	0
DMU_{20}	0.883	16	10	6	9 12 6 13	0.050 0.042 0.360 0.521	0
Mean Efficiency = 0.934							

6.3.2.2 DEA with VRS Scale Assumption

In a multi-stakeholder situation like TES, significant variation is observed in expectations and perceptions of the stakeholders when they attempt to assess the quality. Unlike CRS model, variation in inputs may not lead to the same level of variation in the output in such situations. In order to address this issue, an extension of CRS model, popularly known as Variable Return to Scale (VRS) model is used and compared with CRS model [231].

The result of VRS-DEA model is compared with the ranking of DMUs proposed by surveying agency as shown in Table 6.3. In contrast to CRS model, only two DMUs viz., DMU_5 and DMU_{18} with efficiency score 0.790 and 0.851 respectively are found to be the DEA-inefficient units using VRS model. The inefficient units can make adjustments in their inputs/outputs looking into their peer groups to become efficient unit. These units may adopt either input-oriented strategy or output-oriented strategy to become efficient. The input-oriented strategy emphasises on achieving current level of output using less inputs than the current level whereas output-oriented strategy rests on achieving higher level of output by same level of inputs. The latter strategy is not only preferred but also suitable for service sectors such as education.

It is clear from Table 6.3 that DMU_5 should refer to the benchmarked units such as DMU_7, DMU_8, DMU_{13} and DMU_{10} in pursuit of improving quality of education with corresponding weightages of 0.220, 0.072, 0.094 and 0.614. Similarly, DMU_{18} should refer to DMU_9, DMU_8, DMU_{13} and DMU_7 with peer weights of 0.205, 0.241, 0.039 and 0.518 respectively to become a 100% efficient unit. The last column of the Table 6.3 indicates that DMU_7, DMU_8 and DMU_{13} become the peer units for two times and DMU_9 and DMU_{10} turn out a single referring institute for the inefficient institutes. The mean efficiency for the twenty DMUs considering variable rating scale (VRS) is 0.982 that happen to be more than that of constant rating scale (CRS). It is interesting to note that only four DMUs qualify as benchmarking units out of eighteen efficient units.

Table 6.3: Results of Data Envelopment Analysis (VRS model)

DMUs (Technical Institutions)	Efficiency	Ranking by surveying agency (a)	Ranking by DEA (b)	Difference (a-b)	Referring Institutes	Peer Weights	Peer Count
DMU_1	1.000	17	1	16	1	1.000	0
DMU_2	1.000	12	1	11	2	1.000	0
DMU_3	1.000	7	1	6	3	1.000	0
DMU_4	1.000	18	1	17	4	1.000	0
DMU_5	0.790	19	2	17	7 8 13 10	0.220 0.072 0.094 0.614	0
DMU_6	1.000	5	1	4	6	1.000	0
DMU_7	1.000	1	1	0	7	1.000	2
DMU_8	1.000	2	1	1	8	1.000	2
DMU_9	1.000	4	1	3	9	1.000	1
DMU_{10}	1.000	3	1	2	10	1.000	1
DMU_{11}	1.000	6	1	5	11	1.000	0
DMU_{12}	1.000	11	1	10	12	1.000	0
DMU_{13}	1.000	9	1	8	13	1.000	2
DMU_{14}	1.000	20	1	19	14	1.000	0
DMU_{15}	1.000	8	1	7	15	1.000	0
DMU_{16}	1.000	13	1	12	16	1.000	0
DMU_{17}	1.000	10	1	9	17	1.000	0
DMU_{18}	0.851	15	3	12	9 8 13 7	0.205 0.241 0.039 0.515	0
DMU_{19}	1.000	14	1	13	19	1.000	0
DMU_{20}	1.000	16	1	15	20	1.000	0
Mean Efficiency = 0.982							

6.3.2.3 Input and Output Slacks

Suppose the DMU A is the most efficient, we can set *Performance Targets* for the inefficient firms to enable them to reach 100 % relative efficiency. Since the DMU A has operated under similar environment and hence using its performance as benchmark is realistic.

Input Target: The input target for an inefficient unit say DMU B is the amount of input which shall be used by the inefficient DMU to produce the same level of output so as to make the DMU efficient one.

*Input Target = Actual Input * Efficiency* (6.10)

Input Slack: For inefficient firms, Input target will be smaller than actual input. The difference between actual input and input target is usually called the Input Slack.

Input Slack for an inefficient DMU = Actual Input – Input Target (6.11)

Input Slack can also be expressed in percentage.

*Input Target = (Input Slack/Actual Input) * 100* (6.12)

Using a similar logic, we can compute *Output Targets* and *Output Slacks*.

Output target = Actual Output/Efficiency (6.13)

Output Slack = Output Target – Actual Output (6.14)

*Output Target Percentage = (Output Slack/Actual Output) * 100* (6.15)

Using DEAP version 2.1 the output and input slacks and target values for the inefficient DMUs both for CRS and VRS models can be calculated that will be useful for the improvement of inefficient DMUs.

6.3.3 Comparisons between Various Rankings

The results from the two models and the surveying agency are shown in Table 6.4. The surveying agency ranks the twenty technical institutions from 1 to 20 using perpetual and factual scores. Based on the efficiency scores obtained from CRS and VRS model, the institutes are also ranked. It is interesting to note that DMU_5 and DMU_{18} show the lowest technical efficiency in both CRS and VRS model. The DMUs with efficiency score of unity is assigned a rank of one and the inefficient units are ranked in descending order of their technical efficiency score. The referring institutes and the corresponding peer weights for DMU 18 are almost same for both CRS and VRS models. But for DMU 5, the referring institute is only DMU 7 in CRS model whereas DMU 7, DMU 8, DMU 13 and DMU 10 are the referring units for VRS model of DEA.

Table 6.4: Comparison between Various Rankings

DMUs (Technical Institutions)	Ranking by surveying agency	Ranking by DEA (CRS)	Ranking by DEA (VRS)	Referring Institutes (CRS)	Referring Institutes (VRS)	Peer Weights (CRS)	Peer Weights (VRS)
DMU_1	17	8	1	6 12	1	0.669 0.222	1.000
DMU_2	12	6	1	7 6	2	0.462 0.467	1.000
DMU_3	7	3	1	13 19	3	0.263 0.676	1.000
DMU_4	18	12	1	7 9 12 6	4	0.245 0.537 0.137 0.027	1.000
DMU_5	**19**	**13**	**2**	**7**	**7** **8** **13** **10**	**1.138**	**0.220** **0.072** **0.094** **0.614**
DMU_6	5	1	1	6	6	1.000	1.000
DMU_7	1	1	1	7	7	1.000	1.000
DMU_8	2	1	1	8	8	1.000	1.000
DMU_9	4	1	1	9	9	1.000	1.000
DMU_{10}	3	1	1	12	10	1.000	1.000
DMU_{11}	6	1	1	18	11	1.000	1.000
DMU_{12}	11	1	1	12	12	1.000	1.000
DMU_{13}	9	1	1	13	13	1.000	1.000
DMU_{14}	20	9	1	8 9 12	14	0.229 0.409 0.308	1.000
DMU_{15}	8	2	1	6 7 12	15	0.027 0.476 0.393	1.000
DMU_{16}	13	7	1	6 7 9 12	16	0.030 0.519 0.012 0.345	1.000
DMU_{17}	10	4	1	6 13 12	17	0.418 0.399 0.099	1.000
DMU_{18}	**15**	**11**	**3**	**7** **9** **8** **13**	**9** **8** **13** **7**	**0.516** **0.203** **0.239** **0.043**	**0.205** **0.241** **0.039** **0.515**
DMU_{19}	14	5	1	7 8 9	19	0.566 0.164 0.163	1.000
DMU_{20}	16	10	1	9 12 6 13	20	0.050 0.042 0.36 0.521	1.000

The average technical efficiency score of the DMUs calculated using output oriented CRS model is 0.934 indicates plenty of scope exists for improvements in Indian technical institutions. The average technical efficiency of DMUs calculated using output oriented VRS model is 0.982. It is worthwhile to interpret the correlation between the various rankings to know the degree of association between various methods. The correlation is calculated using the Spearman's rank correlation coefficient (r_s) as follows:

$$r_s = 1 - \frac{6\sum_{i=1}^{n}(X_i - Y_i)^2}{n(n^2-1)} \tag{6.22}$$

Where

X_i is the rank of the ith observation of variable X

Y_i is the rank of the ith observation of variable Y

'n' is the number of pairs of observations

High degree of correlation (r_s = 0.888, p = 0.000) between the ranks assigned by the surveying agency and DEA ranking using CRS model has been observed. Similarly, the correlation coefficient between rankings of the surveying agency and DEA ranking using VRS model is 0.318 (p = 0.172) which indicates a very weak relationship between the two rankings. But, an average degree of correlation is found between the ranks assigned by DEA rankings using CRS and VRS model (r_s = 0.512, p = 0.021).

In order to check for existence of significant difference between technical efficiency (TE) scores calculated using the two models i.e. CRS and VRS, a paired two-sample t-test for means is carried out [232].

The following hypotheses are set to conduct the test.

$$H_o : TE\ from\ DEA-CRS = TE\ from DEA-VRS$$

$$H_1 : TE\ from\ DEA-CRS \neq TE\ from\ DEA-VRS$$

The t-test is applied using SYSTAT VERSION 7.0. The result shows the p-value of 0.001 allowing us to reject the null hypothesis with an α (probability of type I error) value as low as 0.01. This allows us to accept the alternative hypothesis that there is a significant difference between the efficiency scores obtained through CRS and VRS models.

6.4 Conclusions

In this chapter an attempt has been made to benchmark the Indian technical institutions based on the technical efficiency score through a methodology called DEA. The analysis facilitates to identify the benchmarking institutions that can be referred by inefficient institutes to become efficient units. Two approaches of DEA viz. Constant Return to Scale (CRS) and Variable Return to Scale (VRS) are considered to obtain efficiency of DMUs. Eight and eighteen institutions are found to be most efficient in CRS and VRS model respectively. The rankings determined by the surveying agency, CRS model and VRS model are compared to acquire a richer knowledge about the relationships between them. The correlation coefficient between the ranking of the surveying agency and CRS model shows a high degree of association (r = 0.888354) whereas rankings of the surveying agency and VRS model exhibit very low degree of association (r = 0.318142). It indicates that conventional ranking method adopted by surveying agencies is not adequate enough. The major drawback of this method is that it assigns equal weightage to all the factors considered. Further, the method lacks in reflecting the true picture on quality as it provides average quality. Moreover, depending on sample size and criteria considered, ranking of institutions vary from one agency to another. Therefore, the conventional ranking is liable to exhibit errors. The correlation coefficient between the two DEA rankings using CRS and VRS models show an average degree of association (r = 0.511773). The paired two-sample t-test indicates that there is a significant difference between the efficiency scores obtained through CRS and VRS models.

The eight benchmarked institutions resulted through DEA-CRS model happen to be premier technical institutions of India. All these institutions possess few specific characteristics favourable for imparting quality education. Being established in 1960s, they have developed sufficient expertise and competence through experience, experimentation and feedback from market. Importantly, superior level of inputs is admitted in such institutions through an entrance examination considered as top class entrance examination in India. Over the years, they have developed best infrastructure facilities for teaching, research and development. Dedicated, highly qualified, knowledgeable and experienced faculties characterise excellent faculty profile that enables to address the academic and learning outcome dimensions of 'EduQUAL'. Enormous public funding, generation of funds through higher degree of consultancy and industry collaboration activities, continuing education and financial assistance by alumni help to acquire best infrastructure facilities, modern and sophisticated instruments, IT facilities and library up-gradation leading to facilitate improving infrastructure and personality development dimensions of EduQUAL. In case of DEA-VRS model, 90% of the selected DMUs are DEA-efficient. However, DMU_5 and DMU_{18} are found to be non-performing DMUs both in CRS and VRS model.

In this study, only the quality items that are relevant for improving the technical education quality have been considered. Other pertinent factors like quality of inputs (students), investment pattern in the institution, funds generation by the institution and research and development activities could have been incorporated in the model for ranking of the technical institutions effectively.

CHAPTER VII

Service Quality Model for Internet Banking

7.1 Introduction

The advent of Information Technology (IT) brought about a great revolution in manufacturing as well as the service sector. The power of WWW (World Wide Web) and global e-commerce are becoming more meaningful with the increasing number of people around the world connecting to the Internet everyday. Technology developments in the area of telecommunications and IT are revolutionizing the service industries and banking sector is a prominent one [233]. Using Internet, banks need not develop a large network of branches. Rather, they can manage with a processing centre that could, in fact, be located anywhere in the world. Online banking provides customers with the ability to access almost any type of banking transactions. The basic services provided by the Internet banks to the customers are balance enquiry, fund transfer, payment of public utilities, e-shopping, enquiry about credit card and ATM (Automated Teller Machine), current exchange and interest rate, news and business information. The customer would get empowered due to a wide choice of services available on the net at competitive cost. Thus, Internet banking presents a convenient and timesaving service for customers compared to traditional banking and service is available on the web for twenty-four hours a day, seven days a week and anywhere they need. For the bankers, online banking presents more opportunity to provide customized services and appropriate supply and demand than the traditional services.

Today, Indian banking industry is in the midst of IT revolution. A great deal of automation is observed in Indian banking industry these days. New private sector banks and foreign banks have an edge over public sector banks as far as implementations of technological solutions are concerned. Bankers in India are continuously looking for the newer know-hows to improve service quality of their banks to gain competitive edge. Therefore, service quality in Internet banking plays a vital role for retaining customers and meeting the customer's satisfaction level [234-248]. In Indian context, quality of service in Internet banking has not been adequately emphasized. Therefore, it is essential to focus on quality of

service in Internet banking. In doing so, it can provide guidelines for the bankers to implement the quality programme in Internet banking.

7.2 Brief Description of Banking System in India

There are basically four categories of banks such as Public Sector Banks, Private Banks, Foreign Banks and Cooperative Banks operating in India that are regulated by Reserve Bank of India (RBI). Besides, there are some subsidiaries of public sector and cooperative banks that are operating in the different parts of the country. The major Public Sector banks are State Bank of India, Allahabad Bank, Andhra Bank, UCO Bank and United Bank of India. The Private Banks include ICICI Bank, HDFC Bank and UTI Bank. The important foreign banks that are operating in India are HSBC, Citibank and ABN-AMRO Bank. As far as the electronic banking is concerned, the private and foreign banks are early adopters of e-banking while the public sector banks are also beginning to hold on to the competition. ICICI Bank and HDFC Bank have taken a leading role in introducing e-banking in India. ICICI Bank is the first one to have introduced Internet banking for a limited range of services such as access to account information. In 1996, other services like funds transfer among its branches and e-trading have been introduced [249]. Other banks such as Citibank, IndusInd Bank and HDFC Bank have adopted the technology in 1999.

The success of Internet banking depends on Internet penetration rate in Indian population. JuxtConsult, a research firm based in New Delhi estimated through survey studies that Indian Internet population is currently over 25 million making the Internet penetration rate for India well below 5% and is expected to grow to 100 million by 2007. Majority of the Internet users are executives and students in cities with higher income group. Over 50% of Web users in Indian metropolitan areas are between the ages of 19 and 30 and 22% between 31 and 40 years of age. Thus, the growth of Internet penetration rate and the users of Internet being young, it creates a great opportunity for flourishing the Internet banking network in the country. The Indian customer is moving slowly but steadily towards Internet banking. A number of banks have either adopted

Internet Banking or are on the threshold of adopting it. The banks started Internet banking initially with simple functions such as getting information about interest rates, checking account balances and computing loan eligibility. Then, the services are extended to online bill payment, transfer of funds between accounts and cash management services for corporate. Recently, banks have started to facilitate payment of e-commerce transactions by directly debiting bank accounts or through credit cards.

7.3 A Brief Scenario of Internet Banking

Furst et al. presented data on the number of national banks in U.S. offering Internet banking and the products and services being offered [234]. Only twenty percent of national banks offered Internet banking in the third quarter of 1999. However, as a group, these “Internet banks” accounted for almost 90 percent of national banking system assets and 84 percent of small deposit accounts. Internet banking tends to rely less on interest-yielding activities and core deposits. Also, Institutions with Internet banking outperformed non- Internet banks in terms of profitability [235]. DeYoung investigated the performance of Internet-only banks and thrifts in the U.S [236]. The empirical analysis found that the newly chartered Internet-only banks substantially underperforms the established banks at first but these performance gaps systematically diminish over time as new banks grow older and larger. The study suggested that the Internet-only banking model might be feasible when executed efficiently. Sathye surveyed the status of Internet banking in Australia [237]. The study found that only two of the fifty-two banks started Internet banking services at that time. However, still there was a lot of room for Internet banking to expand in Australia. Hasan found that online home banking has emerged as a significant strategy for banks to attract customers. Almost seventy five percent of the Italian banks have adopted some form of Internet banking during the period 1993-2000. It also found that the higher likelihood of adopting active Internet banking activities is by large banks, banks with high involvement in off-balance sheet activities, past performance and high branching network [238]. Janice et al. based on interviews

with four banks in Hong Kong noted that banks view the Internet as being a supplementary distribution channel for their products and services in addition to other forms of distribution channels such as Automated Teller Machines (ATMs), phones, mobile phones and bank branches. Basic transactions and securities trading are the most popular types of operations that customers carry out in Internet banking [239]. Guru et al. examined the various electronic channels utilized by the local Malaysian banks and also assessed the consumers' reactions to these delivery channels [240]. It was found that Internet banking was nearly absent in Malaysian banks due to lack of adequate legal framework and security concerns. However over 60 percent of the respondents were having Internet access at home and thus represented a positive indication for PC based and Internet banking in future. Awamleh et al. found that banks in Jordan are not fully utilizing facilities available with web banking [241]. The study revealed that Jordanian banks have been successful in the introductory phase of web banking. However, Jordanian banks are required to move towards web banking usage with a view to conducting real financial transactions and improving electronic customer relations. Jasimuddin found that within one year of the introduction of Internet service in Saudi Arabia, Saudi banks had at least decided on their Internet presence [250]. Seventy-three percent of the Saudi banks possessed their own web sites and twenty five percent of the web sites were offering full services over Internet. The banks viewed the Internet as a key alternative delivery channel.

In Indian context, many publications throw light over the importance of Internet banking and also its prospects for the Indian banking industry. Unnithan et al. studied the drivers for change in the evolution of the banking sector in two countries such as Australia and India [251]. The paper found that Australia is a country with Internet ready infrastructure as far as telecommunication, secure protocols, PC penetration and consumers' literacy is concerned whereas India is overwhelmed by weak infrastructure, low PC penetration, developing security protocols and consumer reluctance in rural sector. Although many major banks have started offering Internet banking services, the slow pace will continue until

the critical mass is achieved PC, Internet connections and telephones. However, the upsurge of IT professionals with growing demands is compelling the administrators to support and develop new initiatives for a faster spread of Internet Banking. Rao et al. provided a theoretical analysis of Internet banking in India and found Indian banks have to go a long way as far as online services are concerned. For online banking to reach a critical mass, there has to be sufficient number of users and the sufficient infrastructure in place [252]. Various authors have found that Internet banking is fast becoming popular in India [253-256]. However, it is still in its evolutionary stage. By the year 2006-07, a large sophisticated and highly competitive Internet banking market will develop. Almost all the banks operating in India are having their websites but only a few banks provide transactional Internet banking.

As discussed in section 2.2.2 in chapter 2 there are a series of articles that observe that Internet banking has revolutionized the banking industry and the banking industry is under pressure to offer new products and services. However, to succeed in today's electronic markets a strategic and focused approach is required. In India, relatively less number of studies has been conducted on the current status of Internet banking and customer satisfaction compared to other countries. Thus, there is a lot of scope for the research to present new ideas concerning Internet banking in India that may be useful to the Indian banking industry. To this end a conceptual framework has been suggested to understand the present scenario of service quality practices in Indian Internet banking system.

7.4 The Conceptual Framework

To understand the characteristics of e-service quality in general and service quality in Internet banking in particular, discussions on various aspects of the customer satisfaction in relation to the traditional and e-service quality is necessary. Widespread literature survey discussed in section 2.2.2 suggests various authors have pointed out several online service dimensions. The most common dimensions of Internet banking for evaluation of customer perceived

service quality of Internet banking from the literature are mentioned in Table 7.1. They are **reliability, accessibility, user friendliness, privacy/security, efficiency, responsiveness and fulfillment.**

Reliability: Reliability represents the ability of the website to fulfill orders correctly, deliver promptly, and keep personal information securely [22]. The importance of reliability has been highly emphasized on information technology. Moreover, Zhu et al. argued that reliability dimension has a direct positive effect on perceived service quality and customer satisfaction in electronic banking systems. Online banks must provide error free service and secure online transactions to make customers feel comfortable [257].

Accessibility: Accessibility refers to making efforts to approach and ease of contact. It means the service is easily accessible by telephone, waiting time to receive service is not extensive, convenient hours of operations and convenient location of service facility [4,47]. According to Yang et al., access includes the list of company's e-mail address, phone and fax numbers, accessibility of service representatives, availability of chat room, bulletin boards and other communication channels [60]. From the perspective of Internet banking service quality, Jun and Cai state that access consists of availability for help, ATM access, phone access, e-mail access and account access [53].

User Friendliness: Loiacono et al. consider two distinct aspects of user friendliness or the ease of use when it is applied to website. They are ease of understanding and ease of navigation. Internet banking sites should make the consumers easy to work with their tasks, easy to understand and read the information, and easy to order products/services. Many system features such as menus, icons, and touch screen are specifically intended to enhance user friendliness [149].

Security/Privacy: Parasuraman et al. defines security as the freedom from danger, risk or doubt, financial security and confidentiality [47]. Based on the research of online services, security implies low risk associated with online transaction, safeguarding personal information (privacy) and safety in completing

online transactions [60]. Zeithaml et al. defines security as the technical functioning of site information that is accurately provided [148]. Jun and Cai state that security is concerned with online transaction safety and customer privacy [52].

Efficiency: Efficiency refers to the ability of customers to get to the website, find their desired products and information associated with it and checks out with minimal effort [64].

Responsiveness: Customers expect that the online banks must respond their inquiry promptly [233]. Responsiveness describes how often an Internet bank voluntarily provides services (e.g. customer inquires, information retrieval and navigation speed) that are important to its customers [4]. Researchers examining the responsiveness of web-based services have highlighted the importance of perceived service quality and customer satisfaction [65,257].

Fulfillment: Fulfillment incorporates accuracy of service promises, having product in stock and delivering the product in the promised time [64]. Therefore, a well-constructed fulfillment policy such as convenient order procedure, fast delivery, and good customer support will make transaction process easy and simple.

Table 7.1: Coverage of Online Service Quality Dimensions in Literatures

Authors	Reliability	Accessibility	User friendliness	Privacy/ Security	Efficiency	Responsiveness	Fulfillment
Johnston (1995)	✓	✓	✓	✓	✓	✓	✓
Johnston (1997)	✓			✓		✓	
Joseph et.al. (1999)		✓	✓		✓		
Nantel (2000)	✓	✓		✓			
Zeithaml et. al. (2000)	✓	✓	✓	✓	✓	✓	✓
Liu & Arnett (2000)	✓			✓		✓	
Jun & Cai (2001)	✓	✓	✓	✓		✓	
Wolfinbarger &Gilly (2002)	✓			✓			
Madu (2002)	✓		✓	✓	✓	✓	
Yang & Jun (2002)	✓	✓	✓	✓			
Broderick & Vachirapornpuk (2002)	✓		✓		✓	✓	✓
Santos (2003)	✓		✓	✓	✓		
Trocchia & Janda (2003)		✓		✓	✓		
Sohail & Shanmugham (2003)		✓	✓	✓		✓	
Jayawardhena (2004)		✓		✓		✓	✓
Yang et.al (2004)	✓	✓	✓	✓			
Yang & Fang (2004)	✓	✓				✓	
Jun et. al (2004)	✓			✓		✓	
Dina et. Al (2004)			✓	✓		✓	
Lee & Lin (2005)	✓	✓		✓		✓	
Gerrard & Cunningham (2005)	✓		✓	✓		✓	

Percentage of coverage	**80%**	**60%**	**60%**	**90%**	**35%**	**70%**	**20%**

In order to achieve better understanding of how Internet affects service quality in banking sector, the proposed seven service quality dimensions are conceptualized to illustrate the overall service quality of the internet banking in relation to customers' and providers' perspective. This has been used as a research framework for the forthcoming discussions (Figure 7.1).

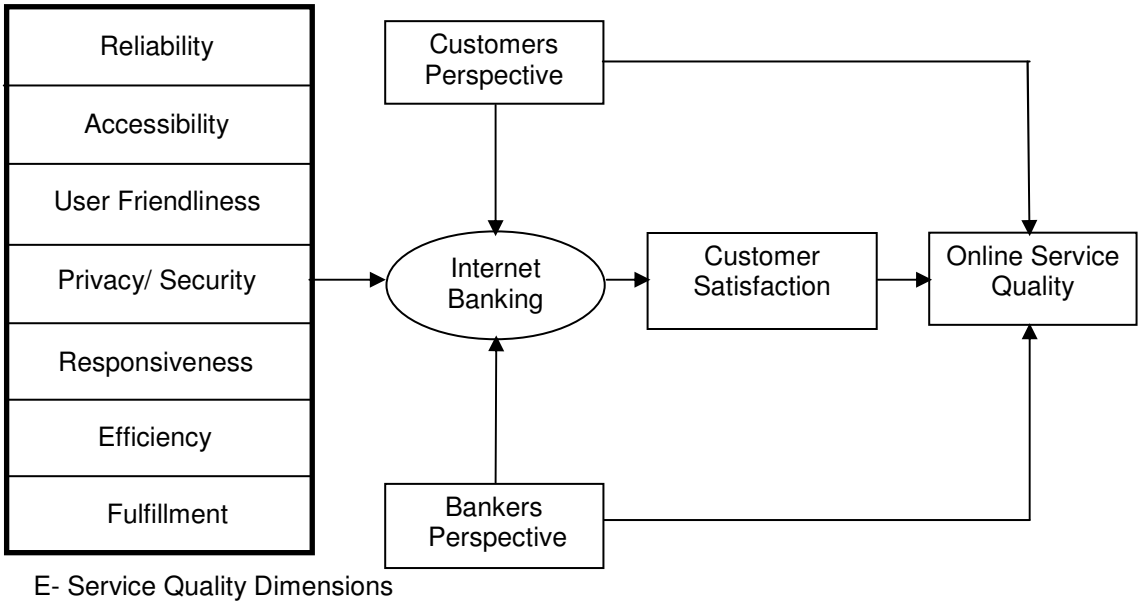


Figure 7.1: The Research Framework

The seven dimensions of Internet banking service quality have been indicated with respect to customer's and banker's perspective. The relationship between customer satisfaction and the online service are also mentioned in the Figure 7.1. Basically, service quality in Internet banking can be viewed from both customers' perspectives and bankers' perspective. From the customers' perspective, service quality is the perceived quality. From the bankers' perspective there are targets and delivered quality. However, bankers are first required to understand the attributes that are significant for the customers' satisfaction to judge the service quality for enhancing banking service [249].

7.5 Hypotheses to Test

With the stiff competitions in Internet banking industry, it is apparent that the service providers need to provide customers with high standard services. To achieve this goal, the bankers are first required to understand the attributes that are used by customers to evaluate the service quality. Therefore, the main purpose of this study is to gain a better understanding of how Internet affects service quality in the banking sector. The following proposition appears to be significant in view of previous discussions.

1. The dimensions reflecting service quality in Internet banking is significantly related to each other.
2. The customer varying in demographical characteristics differs significantly in their levels of satisfaction with the dimensions determining service quality.
3. The dimensions significantly determine the customer satisfaction in Internet banking.

7.5.1 Survey Design

In view of the detailed discussions presented in section 7.5 and 7.6, a questionnaire survey was conducted on order to determine the dimensions of Internet banking and their relationships with the customer satisfaction. Before finalizing the questionnaire and to obtain a more comprehensive picture of customers' perception on Internet banking, a discussion was conducted in mid-January 2006 with ten potential Internet users who had direct experience in using Internet banking for transactions. This was followed by a detail discussion with the managers of four banks including public sector, private sector and foreign banks regarding the various problems faced by customers and providers of Internet banking. The discussions explored positive and negative Internet banking experiences, criteria used in evaluating Internet banking service quality and the characteristics of good or bad Internet service quality. An exhaustive literature review on Internet banking was also carried out for the purpose of preparing the questionnaire. From these qualitative studies, an exhaustive

questionnaire was prepared in which items are included for various aspects of the Internet banking and its service quality. The questionnaire consists of two parts. The first part consists of twelve questions concerning the demographic information of the respondents such as age, gender, education, income, computer literacy and profession. The second part consisting of thirty-two questions explore the respondent's perception about the service quality of Internet banking. Finally, the overall ranking of the customer about the quality of Internet banking and their suggestions have been obtained at the end (Appendix 7.1).

7.5.2 Sample Selection

The customers who have at least one year of experience in Internet banking in India and willing to participate in this study are identified by visiting retail branches/ATM branches of different banks across the country. The e-mail IDs is collected from them with a request to respond the questionnaire correctly and quickly. The collection of e-mail ID was done during January-March 2006. Non-Probabilistic sampling method has been employed in this study because it provides a range of alternative techniques based on researcher's subjective judgment [270]. The most common type of non-probabilistic sampling method which is applied in this study is 'convenience sampling' through which a researcher selects sample members who can provide required information and available to participate in the study. The researcher uses the subjective methods such as personal experience, personal contact and expert judgment to select the elements in the sample in a convenient manner. A Total number of 2500 IDs are collected from the selected banks (1556 numbers from public sector banks, 647 numbers from private sector bank and 297 numbers from foreign bank). The survey instrument is administered through the medium of Internet with an e-mail attachment of the questionnaire to all 2500 IDs collected. By the cut-off date (31st March, 2006), 529 messages are returned undelivered, 605 did not respond and 223 responses are incomplete. Finally, 1143 usable responses has been received which is about 46% of the total e-mails sent. The public sector, private

sector and foreign banks have the share of 700 (45%), 330 (51%) and 113 (38%) responses respectively.

7.5.3 Demographic Profile

The demographic characteristics of the respondents are shown in the Table 7.2. Most of the respondents are between the age group of 20-30 and 30-40 years. For the private sector and foreign banks, the respondents in the age group of 40-50 years are significantly more than public sector banks. For all categories of banks the number of male respondents dominates the female respondents. Majority of the respondents are from the urban area and most of them are having bachelor or master degrees. In public sector bank forty two percent have monthly income of Rs.15,000-Rs.50,000 whereas both in private sector and foreign banks the monthly income of the respondents are between Rs.50,000-Rs.1,00,000 and more than Rs.1,00,000. A bulk of the respondents is able to use the computers for their Internet banking and most of them have started using Internet bank for the last two years. They browse online banking within 1-15 days. The majority of the respondents use Internet banking for account enquiry followed by funds transfer, debit and credit card information and e-shopping. The number of respondents using online trading seems to be lowest. In private and foreign banks, most of the respondents are single bank users whereas in public sector banks fifty percent of the respondents and other fifty percent use more than one bank.

Table 7.2: Demographic Profile of Respondents

No	Characteristics	Level	Public Sector		Private Sector		Foreign Bank	
			Response	%	Response	%	Response	%
1	Age	Up to 20 years	0	0	33	10	09	08
		20-30 years	420	60	148	45	35	31
		30-40 years	231	33	119	36	40	35
		40-50 years	49	07	17	05	26	23
		50-60 years	0	0	13	04	03	03
		60 years and above	0	0	0	0	0	0
2	Gender	Male	581	83	297	90	104	92
		Female	119	17	33	10	9	08
3	Residence	Urban	644	92	314	95	113	100
		Rural	56	08	16	05	0	0

4	Education	Up to high school	0	0	0	0	0	0
		Bachelor degree	448	64	247	75	74	66
		Master degree	126	18	56	17	27	24
		Doctor degree	126	18	27	08	12	10
5	Profession	Students/faculty	315	45	102	31	21	19
		Employee	175	25	96	29	39	35
		(Govt./Private)	56	08	66	20	13	10
		Employee (Industry)	14	02	0	0	05	05
		Retired person	56	08	39	12	28	25
		Business	84	12	27	08	07	06
		Others						
6	Income	Less than Rs.	56	08	10	03	0	0
		15,000	322	42	66	20	20	18
		15,000 to 50,000	231	33	158	48	59	52
		50,000 to 1,00,000	119	17	96	29	34	30
		More than 1,00,000						
7	Level of computer literacy	Don't know any thing at all about computer.	0	0	0	0	0	0
		Have some knowledge about it but not enough to use computer.	70	10	20	06	0	0
		Have more knowledge about it and be able to use them.	350	50	201	61	84	74
		Know lot about computer	280	40	109	33	29	26
8	length of use	Less than 1 year	245	35	188	57	38	34
		1-2 years	413	59	125	38	41	36
		2-3 years	42	06	17	05	30	27
		3-4 years	0	0	0	0	04	03
		4 years and more	0	0	0	0	0	0
9	Duration of access	Every day	84	12	53	16	30	27
		1-7 days	231	33	79	24	37	33
		7-15 days	126	18	102	31	21	18
		15-30 days	140	20	73	22	17	15
		Occasionally	119	17	23	07	08	07
10	Type of Service used	Account enquiry	581	83	267	81	85	75
		Funds transfer	231	33	185	56	56	50
		Insurance premium	56	08	73	22	06	05
		Investment	119	17	92	28	26	23
		E- shopping	231	33	188	57	95	84
		Tax-service	63	09	30	09	0	0
		Credit and debit card	294	42	264	80	106	94
		Brokerage	0	0	79	24	14	12
		Foreign exchange trading	14	02	23	07	41	36
		Online trading	0	0	43	13	11	10
11	Bank users	One bank	350	50	247	75	88	78
		More than one bank	350	50	83	25	25	22

7.5.4 Data Reduction

To remove the redundant (highly correlated) variables from the survey data and to reduce variables into definite number of dimensions, factor analysis is done by the Principal Component extraction method with Varimax rotation using **SPSS 14.0.** The original 32 items of the questionnaire of Internet banking service quality after factor analysis reduces to 26 items and settled with seven dimensions. The sorted rotated values of factor loading with minimum value of 0.5 or more are considered and are shown in the Table 7.3 below.

Table 7.3: Sorted Rotated Factor Loadings with Varimax Rotation

Sl. No.	Sl. No. in the Questionnaire	Variables	Factor Loadings	Dimensions
1	4	Information that is provided is accurate	0.947	X_1
2	1	The web pages are functioning properly	0.840	
3	5	Information content and texts are easy to understand	0.783	
4	3	Links are problem free, accurate and the pages download quickly	0.587	
5	6	The bank's site has unrestricted access to all financial information	0.959	X_2
6	7	The bank provides the updated technology regularly for Internet banking	0.799	
7	9	The web pages don't freeze after you have put in all your information	0.615	
8	8	The bank is easy to approach and easy contact	0.605	
9	11	The website is available in the language you can understand	0.859	X_3
10	10	The bank's site provide information about the transactions and products	0.841	
11	13	Personalization of bank's site for customers' personal requirement	0.788	
12	12	The bank authority care to listen to your queries and meet your personal needs	0.672	
13	16	You can rely on bank for not misusing your information	0.893	X_4
14	15	You can rely on the personal information remaining in the register	0.883	
15	19	The bank provides financial security and confidentiality	0.700	
16	17	The bank's site is secured for your credit card information	0.560	
17	22	The bank's site is easy to navigate and simple to use	0.833	X_5
18	20	The speed of login of your account is fast	0.812	
19	24	The speed of logout of your account is fast	0.807	

20	23	It is easy to find policy and notice statement on the bank's site	0.750	
21	29	The bank takes care of problems properly and compensate for the problems they create	0.936	X_6
22	27	Knowledge and skill of the contact personnel	0.836	
23	26	You are able to talk to a customer service representative in the bank over telephone	0.604	
24	25	The bank is willing to help customers, provide appropriate information and prompt service	0.557	
25	31	The bank's site performs the service right at the first time	0.812	X_7
26	30	The bank's site provides a confirmation of the service ordered quickly	0.740	

Seven dimensions have been extracted from Principal Component Factor Analysis and named as follows with the number of variables as per Table 7.3:

1. Reliability (X_1) : Variable 1-4
2. Accessibility (X_2) : Variable 5-8
3. User friendliness (X_3) : Variable 9-12
4. Privacy/Security (X_4) : Variable 13-16
5. Efficiency (X_5) : Variable 17-20
6. Responsiveness (X_6) : Variable 21-24
7. Fulfillment (X_7) : Variable 25-26

It is a coincidence that the above seven dimensions are exactly same as the dimensions considered in conceptual framework (section 7.6). This is because the items selected for the questionnaire survey are mostly related to these dimensions. Hence, the factor loadings of the items reduce to seven factors that can be appropriately named as the dimensions considered in the conceptual framework.

Generally, factor loading represents how much a factor explains a variable. High loading indicates that the factor strongly influence the variable. Assuming a factor loading of more than 0.80 as having high impact on the variables, it is concluded from Table 7.3 that some variables that are less than 0.80 need attention for the quality improvement of Internet banking in India. They are variable 3 and variable 4 in the 'Reliability' dimension. In the 'Accessibility' dimension, variable 6, variable 7 and variable 8 show factor loading less than

0.80. Furthermore, variable 11 and variable 12 have weak influence for the dimension 'User friendliness'. Similarly, variable 15 and variable 16 do not have strong effect on the dimension 'Privacy and Security'. But in the dimension X_5 (Efficiency), only one variable i.e. variable 20 has weak impact on that dimension as the factor score is below 0.80. Variable 23 and variable 24 in 'Responsiveness' dimension and variable 26 in 'Fulfillment' seem to have less influence on that particular dimension. The Communalities displays a range from 80% to 100% (max = 97% and min = 83.5%) indicating the variables are explained better by the factors as it is closer to 1. The percentage variance equals to 91.7%.

7.5.5 Validity and Reliability of the Instrument

The internal consistency or the reliability of the total response (1143) is tested by computing the Cronbach's Alpha using SPSS 14.0. The value of alpha for each dimension is 0.775, 0.801, 0.727, 0.950, 0.714, 0.852 and 0.766 respectively and the combined alpha value for all the items is 0.950. An alpha value of 0.70 or above is considered to be acceptable for demonstrating internal consistency of the established scales [191]. In this case, all the values of alpha well exceed the obligatory requirement. The value of Kaiser-Meyer-Olkin (KMO), which is a measure of sampling adequacy, is found to be 0.751 indicating that the factor analysis test has proceeded correctly and the sample used is adequate as the minimum acceptable value of KMO is 0.5 [192]. Therefore, it can be concluded that the matrix did not suffer from multicollinearity or singularity. The results of Bartlett test of Sphericity shows that it is highly significant (sig. = 0.000), which indicates that the factor analysis processes is correct and suitable for testing multidimensionality [192]. Therefore, the statistical and factor analysis tests for the responses has resulted that the proposed items and dimensions of the instrument are sound enough to measure the service quality in Internet banking and hence can be used for further analysis.

7.6 Analysis of the Results

The actual responses of all th . ›ndents are averaged across the seven dimensions and are plotted against the respondent score (Figure 7.2). The graph shows that the customers rate the dimensions such as reliability, accessibility, privacy/security, responsiveness and fulfillment between 5 and 6. It means that the respondents rate the above dimensions between 'somewhat agree' and 'partially agree' with the facilities supplied by the bankers and the overall service quality of the Internet bank. The dimensions 'user friendliness' and 'fulfillment' show the customer rating below 5. As per the scores assigned by the customers, 'reliability' is given maximum score by the respondents indicating the customers are generally satisfied with the service they are getting from the bankers. The least score has been given to 'user friendliness' leading to the dissatisfaction of customers and suggesting the providers need to improve the service items like 'The bank's site performs the service right at the first time' and 'providing confirmation of the service ordered quickly'. However, it is evident from histogram plotted for all the 26 items against the respondent's average score, the items rated below five are eight in number. They are variable 8, variable 9, variable 11, variable 12, variable 14, variable 24 and variable 26 in which variable 12 has the lowest score i.e. below 4 (no opinion). This suggests that the 'personalization' in the bank's websites has to be further improved in order to improve the Internet banking service quality (Figure 7.3).

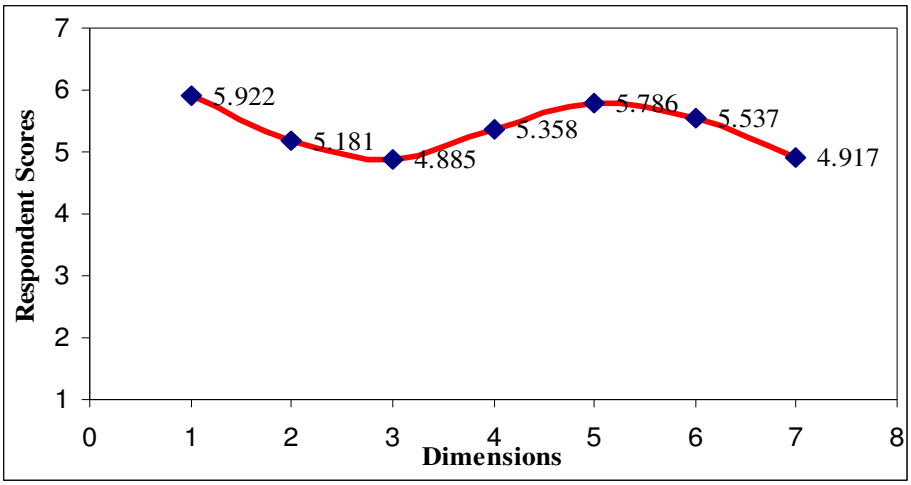


Figure 7.2: Performance of Service Quality Dimensions

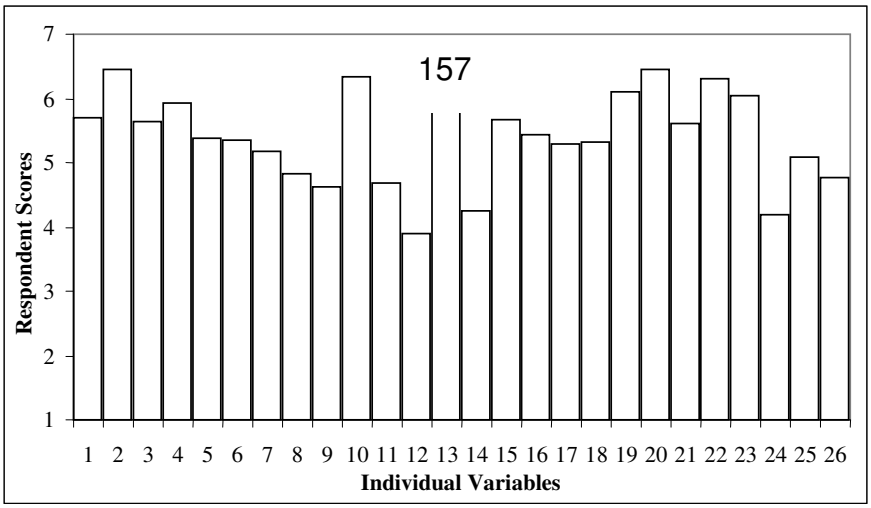


Figure 7.3: Performance of Service Quality Items

The importance of dimensions discussed above considers the perceptions of the customer irrespective of the categories of the banks (public sector, private or foreign banks). However, in actual situation, when the survey is carried out separately for different categories of banks, the importance of the dimensions may vary according to the customers' point of view. Therefore, to get insight to the various dimensions of Internet banking service, the nature of complaints and Frequently Asked Questions (FAQs) by the customers have been discussed with the managers of the three categories of banks viz., public sector, private or foreign banks. The numbers of complaints in each type of banks during two months (August-September 2006) are noted. The complaints are analyzed and observed the suitability to the various dimensions. The dimensions that have maximum number of complaints for each bank are analyzed in order to provide better guidelines to the bank managers.

As per discussions with the bank managers in public sector banks, 'efficiency' gets maximum number of complaints by the customers. Generally, in the standard condition, the login of accounts should take a few seconds but most of the customers experience delay in login and logout of their accounts. The policy and notice statement on the bank's site are not easily traceable and also the customer face difficulty in navigation of bank's website. The other major

complaints being the web page not functioning properly, information provided by the banks are not accurate and the contents in the website are not easily understandable. These are some of the service quality items that need to be focused by the managers of the public sector banks to improve the service quality in Internet banking. To satisfy the customers and thereby improving the service quality in Internet banking, one of the leading public sector bank, State Bank of India (SBI), has offered varieties of customer care features. Customers can lodge their complaints through e-mail, telephone or directly to the contact personnel in the bank. Customers of the Bank can meet senior executives of the Bank on 15th of every month (between 3.00 p.m. and 5.00 p.m.) without any prior appointment and discuss issues relating to their accounts/banking transactions. In case, excessive delay in resolving their problems is experienced, customers can contact the helpline of the Local Head Office under whose control the branch functions. Thus, these are some of the measures the public sector banks employ to improve the customer satisfaction.

The customers of the private sector banks emphasize more on dimension 'privacy/security'. As technology grow, the risk of the web crime by hiking the information of the customer from the bank's database also increases. Therefore, majority of customers question about the safety and privacy of their personal information in the Internet banking. One of the leading private sector banks, ICICI bank, employs a range of security features for its online banking service. These are

1. Firewall: This is a virtual electronic fence that prevents unauthorized access to the ICICI bank server.
2. 128-bit Secure Socket Layer (SSL): It is a protocol designed to enable applications to transmit information back and forth securely in the World Wide Web.
3. Two levels of passwords for executing financial transactions.
4. Secured funds transfer and bill payment.

Similarly, analyzing the complaints and FAQs for the foreign banks, it is noted that most of the complaints are related to the dimensions 'reliability',

‘efficiency’ and ‘security’ of Internet banking service. To attend the requirements of the customer, Citibank India has introduced a single secure Internet password to access all accounts of customers so that the customers don’t have to worry about remembering different passwords thus increasing the efficiency and security of Internet banking. To ensure additional guarantee of security, Citibank introduces the Online Authorization Code (OAC) process for all online fund transfer starting November 1st, 2006. The OAC is a 6-digit code used to authorize every payee for whom the customer wishes to transfer funds, pay credit card bills or issue demand drafts. This bank also employs the virtual keyboard login as the state of the art security measure to provide the customers with increased security in Internet banking. The other important features for providing protection and secure environment in Internet banking in Citibank includes secured login using 128-bit encryption, automatic time out, automatic lock out and strict adherence to the regulatory standards.

7.6.1 Correlations between the Dimensions

To find the degree of association between the identified dimensions, a correlation analysis is performed. The Pearson correlations between the dimensions show that most of the dimensions in general are significantly related to each other at 0.01 and 0.05 significant level. The correlation coefficients between the various dimensions are calculated and shown in Table 7.4.

Table 7.4: Correlation between Dimensions

Dimensions	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1	1						
X_2	.731** .000	1					
X_3	.377** .000	.091** .004	1				
X_4	.398** .000	.278** .000	.644** .000	1			
X_5	.086** .000	.081* .011	.389** .000	.404** .000	1		
X_6	-.200** .000	.018 .562	.022 .491	.265** .000	.015 .645	1	
X_7	-.190** .000	.066* .037	-.130** .000	.048 .129	-.128** .000	.751 .000	1

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

It is interesting to observe that highest degree of significant positive correlation exists between X_7 (Fulfillment) and X_6 (Responsiveness). A high degree of significant positive correlation is also observed between reliability (X_1) and accessibility (X_2), Security (X_4) and user friendliness (X_3). Again most number of negative correlations is observed in the row containing X_7 with X_1, X_3, X_5, but these correlations are of low degree.

7.6.2 Demographic Characteristics of the Respondents

There are eleven demographic characteristics considered in Table 7.2. In this work the response of the gender for some of the important characteristics such as age, income and profession are considered to observe the variation in their opinion. Therefore in order to investigate the impact of service quality dimensions on these selected demographic profile of the respondents, a two-sample t-test to examine whether the mean difference in the response rate of male and female from various professions are statistically significant or not is conducted. The hypothesis set for t-statistics is as follows:

Null hypothesis: H_o: $\mu_1 - \mu_2 = 0$

Alternative hypothesis: H_1: $\mu_1 - \mu_2 \neq 0$

Level of significance: $\alpha = 0.01$

Criterion: Reject null hypothesis if $t > t_{\alpha/2}$ or $t < - t_{\alpha/2}$

where

μ_1 = Average response of male respondents

μ_1 = Average response of female respondents

$t_{\alpha/2}$ = t-statistic values from standard table

$$\text{t-statistics,} \quad t = \frac{\mu_1 - \mu_2}{\sqrt{(n_1 - 1)\, s_1^2 + (n_2 - 1)\, s_2^2}} \times \left[\sqrt{\frac{n_1 n_2\, (n_1 + n_2 - 1)}{(n_1 + n_2)}} \right] \qquad (7.1)$$

Looking at the demographic profile of the respondents, we found that all the respondents have education above the graduation level. This study is limited to the urban population and in future it can be extended to the rural areas in a large scale. Most of the respondents are having good knowledge of operating

computers and they use the computer for Internet banking frequently. In order to investigate the impact of service quality dimensions on the demographic profile of the respondents, we conducted two-sample t-test to examine whether the mean difference in the response rate of male and female respondents for various characteristics are statistically significant or not. The responses of male and female for various professions, age group and income group are sorted out from the main survey data for the two-sample t-test. Table 7.5 shows the p-values of two-sample t-test for male and female for different conditions.

Table 7.5: t-test for Male and Female for Various Conditions

Dimensions	Student/Faculty				Employees (Govt./Private)				Employees (Industry)				Business			
	C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4	C_1	C_2	C_3	C_4
1. Reliability	0.001	0.005	0.472	0.378	0.003	0.000	0.220	0.389	0.000	0.001	0.003	0.068	0.363	0.000	0.000	0.181
2. Accessibility	0.131	0.005	0.004	0.238	0.261	0.000	0.000	0.209	0.026	0.003	0.007	0.277	0.000	0.000	0.001	0.001
3. User Friendliness	0.002	0.341	0.142	0.245	0.000	0.312	0.119	0.166	0.003	0.041	0.129	0.401	0.274	0.079	0.044	0.000
4. Privacy/Security	0.001	0.010	0.000	0.176	0.000	0.302	0.000	0.270	0.238	0.000	0.000	0.001	0.389	0.000	0.000	0.103
5. Responsiveness	0.021	0.003	0.000	0.075	0.027	0.000	0.000	0.344	0.000	0.340	0.000	0.000	0.003	0.044	0.013	0.012
6. Efficiency	0.327	0.368	0.002	0.209	0.063	0.144	0.000	0.294	0.352	0.149	0.248	0.003	0.000	0.464	0.000	0.001
7. Fulfillment	0.121	0.002	0.000	0.001	0.004	0.000	0.305	0.000	0.000	0.000	0.232	0.002	0.121	0.000	0.008	0.184

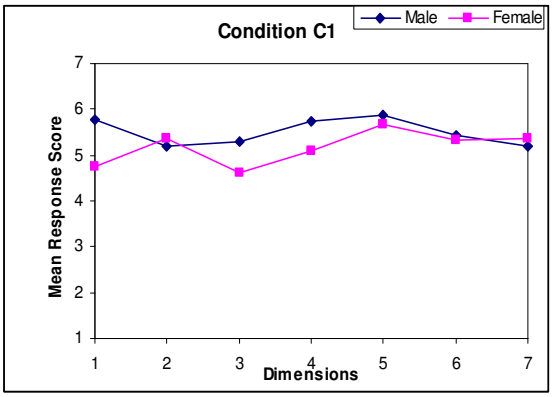
Note:

P-value ≤ 0.01; the difference between the two sample means (male and female) is statistically significant.
P-value ≥ 0.01; the difference between the two sample means (male and female) is statistically not significant.

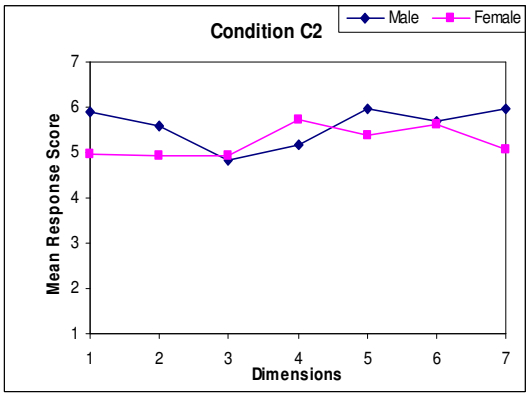
C_1 = Age : Below 40 years
Income : Below Rs. 50,000
C_2 = Age : Below 40 years
Income : Above Rs. 50,000
C_3 = Age : Above 40 years
Income : Below Rs. 50,000
C_4 = Age : Above 40 years
Income : Above Rs. 50,000

The analysis of the results in Table 7.5 has been done dimension-wise to show the statistically significant difference in the gender views. It is interesting to note that there is no significant difference in the opinion of male and female for the categories C_3 and C_4 on the dimension 'reliability' across all classes of respondents, except the business class where C_3 is significant. Similarly, in the dimension 'accessibility' there is no difference in the categories C_1 and C_4. Again the exception is observed in the business class. In the dimension 'user friendliness' there is no significant difference in the judgment of respondents in the categories C_2, C_3 and C_4. The exception observed is C_4 in business class again. Moreover in business class the category C_1 is not statistically significant. In case of dimension 'privacy/security', there is no significant difference in the perception of respondents corresponding to the category C_2 and C_4 except for the opinion of the industrial employees for which the difference between the perspectives of male and female in the above classes are statistically significant. A similar trend can be observed for the dimension 'responsiveness' where all the respondents in the categories C_1 and C_4 demonstrate significant difference in the average response of male and female except the industrial employees. In the 'efficiency' dimension, there is no significant difference in the view of male and female in the categories C_1, C_2 and C_4 for all the respondents, excepting business class. However, for the respondents of business classes the difference is significant in the categories C_1 and C_4. Finally, a mixed result is observed in case of the dimension 'fulfillment'. There is no significant difference between the perceptions of male and female for the categories C_1 and C_2 for students and faculties, C_1 and C_3 for government/private employees, C_3 and C_4 for industrial employees and C_1, C_3 and C_4 for business classes respectively.

The average responses of male and female for each category of customer have been shown in Figure 7.4 to 7.7. The above result shows that the business class differs from other classes in their perception about the service quality of Internet banking.



(a)



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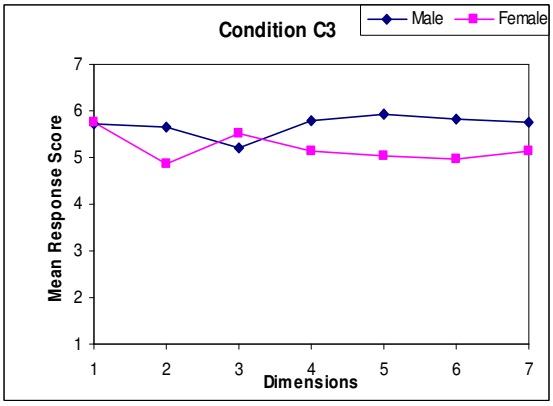

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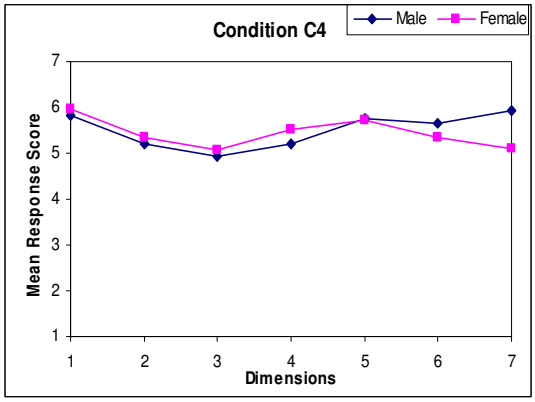
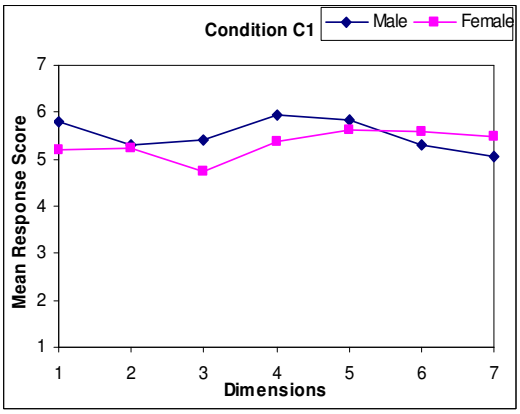
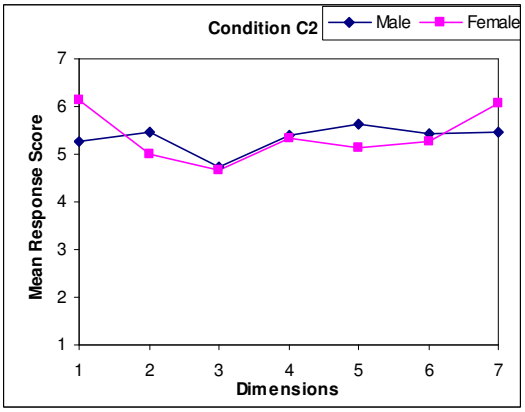


(d)

Figure 7.4: The Average Responses of Male and Female for Students/Faculty for Various Conditions



(a)



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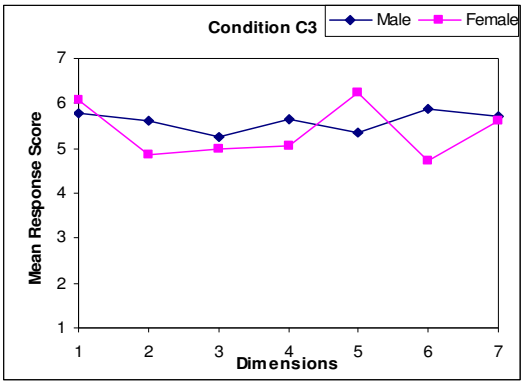

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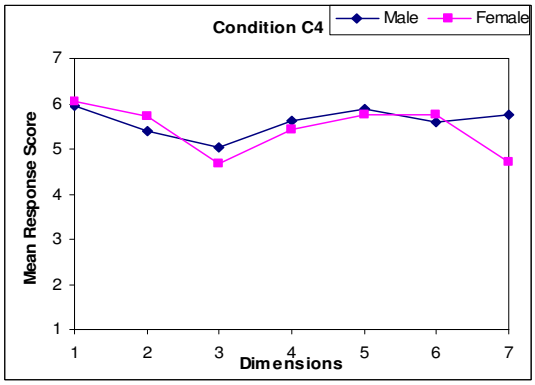
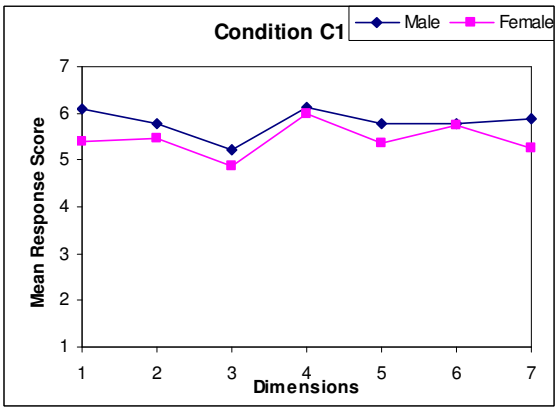
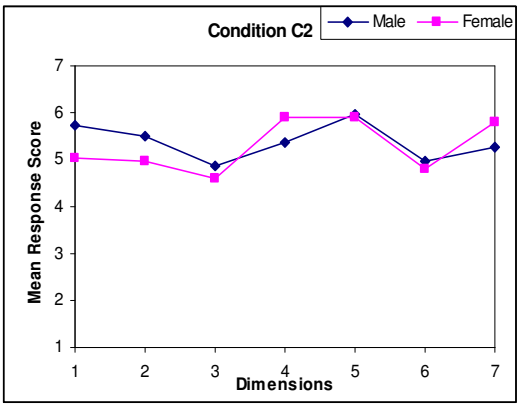


(d)

Figure 7.5: The Average Responses of Male and Female for Employees (Govt. /Private) for Various Conditions



(a)



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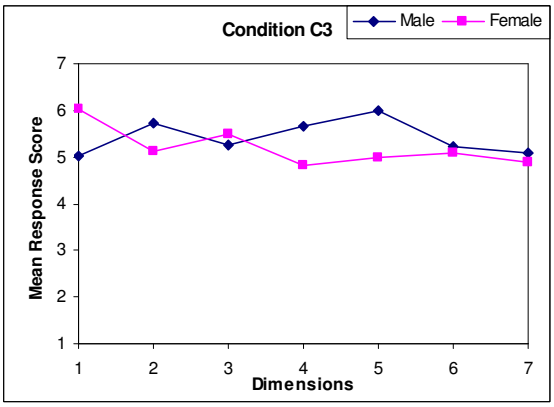

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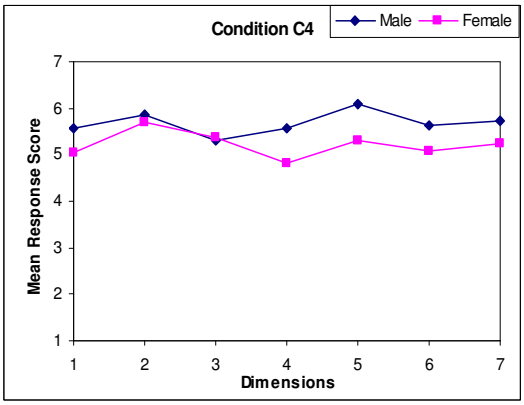

(d)

Figure 7.6: The Average Responses of Male and Female for Employees (Industry) for Various Conditions

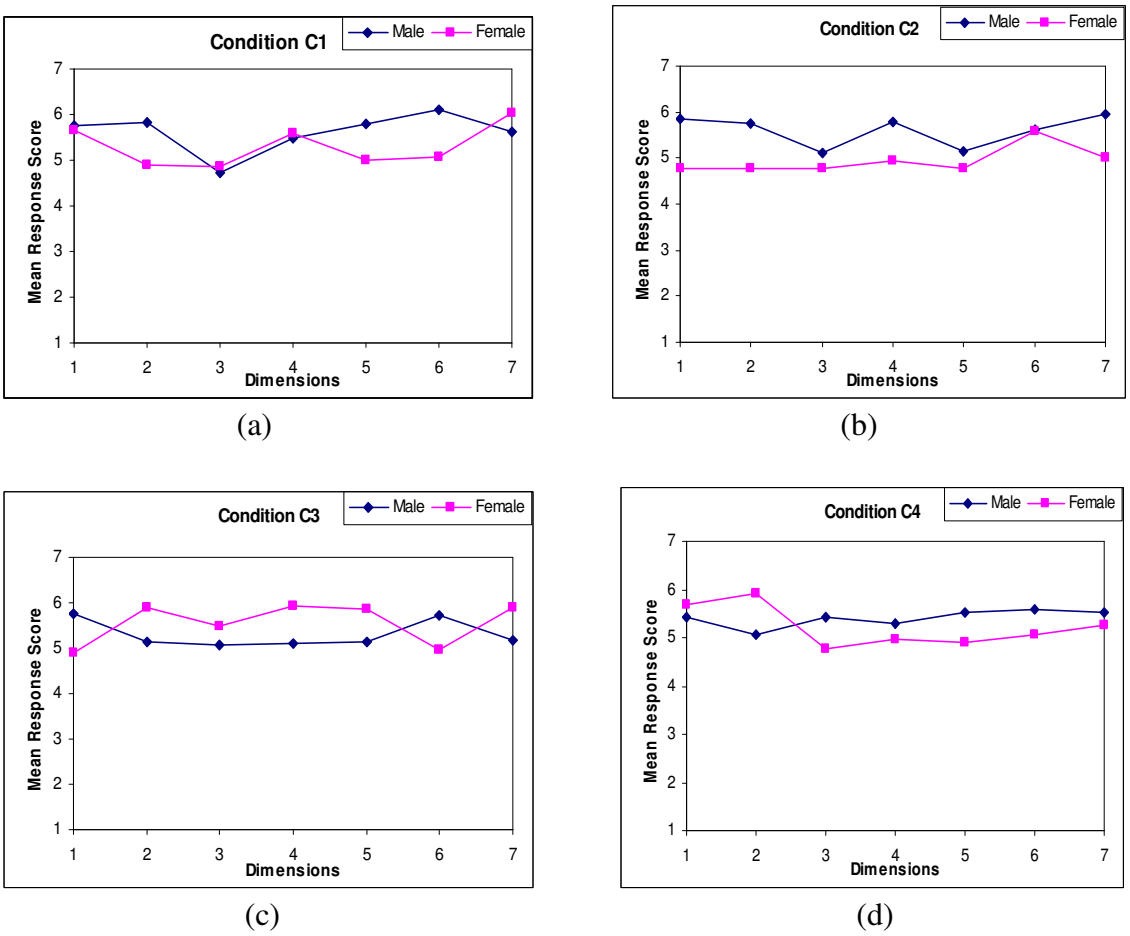

Figure 7.7: The Average Responses of Male and Female for Business Personnel for Various Conditions

7.6.3 The Regression Analysis

To gain a deeper understanding of the relationship between the customer satisfaction in the Internet banking and the identified dimensions, regression analysis has been conducted using the software SPSS 14.0.

Two variables in the regression equation as follows:

Independent Variables: The proposed seven dimensions are treated as the independent variables for the regression equation. They are: 'Reliability' (X_1), 'Accessibility' (X_2), 'User Friendliness' (X_3), 'Privacy/Security' (X_4), 'Efficiency' (X_5), 'Responsiveness' (X_6) and 'Fulfillment' (X_7).

Dependent Variable (Y): The customer satisfaction in the quality of Internet banking service is treated as dependent variable.

The mathematical representation of the regression equation is as follows:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 \quad (7.3)$$

Where,

b_0 = Constant, Value of dependent variable when value of independent variables are zero

= Also called intercepts, because it determines where the regression line meets the Y-axis.

$b_1 \ldots\ldots b_7$ = Coefficients, that represents the estimated change in mean value of dependent variable for each unit change in the independent variable values.

The results of the regression analysis are shown in Table 7.6. Putting the coefficients from the Table 7.6, the regression equation will be in the following form

$$Y = 1.93 + 0.0970 X_1 - 0.133 X_2 - 0.105 X_3 + 0.0446 X_4 - 0.0910 X_5 + 0.806 X_6 + 0.0095 X_7 \quad (7.4)$$

Table 7.6: Relationship between Customer Satisfactions and Dimensions

Independent Variables	Coefficients	Std. Error Coefficient	T	P
Constant	1.9332	0.2683	7.21	0.000
X_1	0.0969	0.0353	2.75	0.006
X_2	-0.1334	0.0552	-2.41	0.016
X_3	-0.1050	0.0388	-2.70	0.007
X_4	**0.0446**	**0.0296**	**1.50**	**0.133**
X_5	-0.0910	0.0323	-2.82	0.005
X_6	0.8057	0.0201	40.11	0.000
X_7	**0.0095**	**0.0161**	**0.59**	**0.554**

Note: R-Sq = 61.2% R-Sq (adj) = 61.0%

It is observed from the Table 7.6 that the relationship between the customer satisfaction (Y) and the various dimension ($X_1 \ldots\ldots X_7$) are more or less statistically significant at 95% confidence level ($p<0.05$). Also, the adjusted R^2

value is 0.61 which indicates that the relationship is statistically significant. Five dimensions, such as, 'Reliability' (X_1), 'Accessibility' (X_2), 'User Friendliness' (X_3), 'Efficiency' (X_5) and 'Responsiveness' (X_6) are statistically significant ($P<0.05$). In addition, the 'Responsiveness' (X_6) dimension has the greatest influence on overall service quality followed by 'Reliability' (X_1), 'Accessibility' (X_2). However, two dimensions, 'Privacy/Security' (X_4) and 'Fulfillment' (X_7) are not statistically significant, indicating further improvement in these dimensions.

7.7 Conclusions

Information Technology (IT) has revolutionized the service industries in the last few years. There has been a substantial growth of Internet-based services both in pure Internet business and traditional companies. One of the key challenges of the Internet as a service delivery channel is to manage service quality that holds a significant role for customer satisfaction and profitability. The purpose of this study is to gain a better understanding of the service quality in the Internet banking sector from a customer's perspective. This study provides initial direction in determining the optimum service quality attributes of Internet banking. The conceptual framework for this research is based on the brain storming sessions with the bank managers, customers and the literature survey. Finally, seven dimensions are proposed namely 'Reliability (X_1)', 'Accessibility (X_2)', 'User Friendliness (X_3)', 'Privacy/Security (X_4)', 'Efficiency (X_5)', 'Responsiveness (X_6)' and 'Fulfillment (X_7)'.

This chapter explores the service quality of Internet banking operative in India from customer's perspective. It is observed that customers are satisfied with the reliability of the services provided by the banks but are not very much satisfied with the dimension 'User Friendliness'. It is observed that the dimension 'Responsiveness (X_6)' is not significantly correlated to 'Accessibility (X_2)', 'User Friendliness (X_3)' and 'Efficiency (X_5)' respectively at a level of 0.01 and 0.05. Also the dimension 'Fulfillment (X_7)' is not significantly correlated to 'Privacy/Security (X_4)' and 'Responsiveness (X_6)' respectively indicating a need to correlate them. A seven dimension model using regression analysis is

developed for measuring the overall service quality of Internet banking. The result indicates that the two dimensions viz. ‘Privacy/Security’ and ‘Fulfillment’ are not contributing significantly towards the overall service quality. This is an implication that the customers feel that bankers fail in providing the services on these two dimensions satisfactorily. It is also observed from the two-sample t-test that the opinion of male and female respondents of business class differs from the other classes as far as their p-values are concerned. Internet banking is going to be very crucial for India having increasing percentage of younger generation population with computer literacy. The limitation of this study is that the result should not be generalized as the service quality of Internet banking has been tested in urban India. Furthermore, a small sample may not be the representative of the whole population and hence, in future, the research can be conduced by taking a large sample to facilitate a robust examination of the service quality of the Internet banking. The future study can also be conducted to identify the relative importance of each dimension. The extension of this study can also include the providers (bankers) perspective to have a better understanding of the problem domain. Validation of model and extension of the results to other industries and also for different cultures are some of the future directions in which the academics and the practitioners can work with to enrich the service quality literature in Internet banking.

CHAPTER VIII

Summary of Findings, Recommendations, and Scope for Future Work

8.1 Introduction

Studies on service quality assessment have attracted the attention of researchers since 1970s. The researchers mainly focus on issues of measuring service quality and its evaluation. However, evaluation and measurement of service quality is largely influenced by the expectations and perceptions of customers because they are directly involved in the process of delivery of service. In addition, type and size of service setting and internal and external factors of the organization influence service quality to a large extent. Therefore, it becomes practically difficult to set the standards and procedures for measuring and evaluating service quality. Further, in a multi-stakeholder situation, the prospective customers or stakeholders interact with the service provider in many ways with different set of mind of expectations (before service) and perceptions (after service). Moreover, service comprises of too many items (or characteristics) and these items widely differ across the industries. Hence, it is desirable to develop a comprehensive methodology to enable the managers to design an instrument consisting of service dimensions and items under each dimension for assessing service quality in a systematic manner. Therefore, in this dissertation work, attempt has been made to provide a general framework for designing the service instrument suiting to most of the stakeholders in a particular service setting and an evaluation methodology for identification of bottlenecks existing in the system. The proposed evaluation methodology has been applied in two different but important service sectors such as 'Education' and 'Banking'. The reason for choosing these sectors lies in the fact that they not only contribute largely on socio-economic development of a developing country like India but also they contrast each other as far as their operational objectives are concerned. 'Education' is primarily treated as philanthropic service whereas 'Banking' is viewed as a profit making service.

The proposed quality assessment methodology has been applied to identify a common minimum number of service items in Indian technical institutions fitting to all important stakeholders for facilitating the administrators to devise methods, procedures and policies that have bearing on improvement of

satisfaction level of the stakeholders. As the service quality in Internet banking is completely different from that of the conventional banks in terms of interaction of customers with the bank due to absence of human interaction in Internet banking, it requires some special kind of service quality improvement strategies. A conceptual framework for quality assessment in Internet banking from customer's and provider's perspective has been proposed.

8.2 Summary of Findings

The important findings of this dissertation work are summarized as follows:

TQM is treated as convenient way of adopting continuous improvement strategies for enhancing quality of product and/or service offered to customers by an organization. The critical appraisal of the literature on TQM practices as mentioned in Chapter 2 demonstrates the fact that only one-fifth of the research articles in last eleven years cover various aspects of TQM implementation in service sector. The low adoption of TQM in service sector is mainly attributed to the intangible characteristics of the services. The following observations in this chapter are worth mentioning.

1. Definition of quality and various issues related to improve quality of manufacturing and service has been addressed in many ways by various quality gurus and different quality awards models. However, the ultimate objective of any quality program focuses on enhancing system effectiveness through elimination of wastes and focus on customer orientation.
2. Study of articles related to TQM implementation of last eleven years reveals an interesting fact that adequate attention has not been diverted by researchers on TQM implementation in service sector owing to difficulties in quantification of service quality and lack of proper understanding on what constitutes service quality.
3. Twenty critical factors for successful implementation of TQM in an organizational context have been identified. However, the set of TQM

characteristics and complementation sequence widely differ among industry types and size of organizations failing to standardize a set of characteristics possibly the best for any organization. Further, consideration of critical factors and TQM practices as such by the researchers are not uniform throughout eleven years.

4. Literature suggests that traditional service quality dimensions for measuring service quality widely vary among proponents depending on its application. Further, it is argued that online service quality dimensions must be different from those of traditional service quality. Online service quality dimensions also vary among various proponents.
5. However, services account for more than 75% of the GDP in most developed countries and same trend is also observed in the developing country like India. **Therefore, exhaustive literature survey on service quality resulted into the conclusion that service sector is a potential area for research and therefore, it is decided to focus on the quality studies for service sector in this research work.**

Assessment of service quality requires a robust instrument capable of measuring various aspects of service delivered by an organization irrespective of service settings once customer needs have been identified. Service quality evaluation procedure not only facilitates system design and implementation of quality planning activities but also provides guidelines to improve upon in certain quality dimensions so that expectations of the customers can be fulfilled. Therefore, Chapter 3 deals with the development of a general methodology and applied to assess technical education in India. In education sector, persistence of intangibility and lack of physical evidence of service makes perceptions of service quality a complex composition and its analysis becomes difficult. Moreover, TES is characterised as multiple stakeholders with different backgrounds and varied behavioral patterns. The responses are collected through a questionnaire survey containing forty-three service quality items relevant to an educational system. The survey data thus collected are analyzed through Principal Component factor analysis with varimax rotation resulting in

twenty-eight quality items with five dimensions. These are named as 'EduQUAL' dimensions. Thus, 'EduQUAL' consists of twenty-eight service quality items classified into five dimensions namely; **Learning outcomes, Responsiveness, Physical Facilities, Personality Development and Academics.**

In order to get an insight of the 'EduQUAL' items and dimensions, the actual survey data are further analyzed statistically. The average responses of the stakeholders are considered for examining the perceptions of the service quality in TES. **It is interesting to note that all the stakeholders emphasize to improve the service quality items in 'academic' dimension highlighting the importance of core area in an educational institution**. A dimension-wise analysis of average response score of the stakeholders indicates slightly different results. The lowest response score has been observed for the dimension 'academics', both for parent and the recruiters. The students and alumni perceived least for the dimensions 'responsiveness' and 'physical facilities' respectively indicating that there is a need to concentrate on these dimensions to improve the service quality in TES. The following remarks are worth mentioning for this chapter:

1. A framework of TES to understand the models of interaction of various stakeholders with TES along with their objectives is established.
2. An instrument known as '**EduQUAL'** for measurement of service quality in technical education system has been proposed. Twenty-eight items under five dimensions constitute various relevant variables for the proposed instrument.

The major contribution of Chapter 4 is to provide a systematic integrated approach for modeling customer evaluation process of service quality applied to technical education. To evaluate the service quality in Indian technical education through use of proposed instrument 'EduQUAL' considering the **expectations** and **perceptions** of customer a back propagation algorithm of neural network is used. Four neural network models viz., **P-E gap, P-only, E-P gap and E&P**

models have been used in this study to find out the best model suitable for TES. Then, sensitivity analysis is carried out to study the impact of changes in service performance of various items (inputs) on customer evaluation of service quality (output) for the best models. The major findings can be summarized as follows:

1. It has been established that **P-E gap model** is the best model suited in TES considering all the important stakeholders.
2. As far as second best model is concerned, it is the E-P for alumni and recruiters and E&P for students and parents.
3. A uniform construct of education quality containing six quality items viz., **(1) training on state-of-the art technology (2) comprehensive learning resources (3) opportunities for campus training and placement (4) close supervision of students work (5) expertise in subjects and well organised lectures and (6) good communication skill of academic staff** suitable to all important stakeholders has been established after sensitivity analysis of the best model.

In order to improve service quality in TES, the system must be designed to address the six common deficient items identified by important stakeholders. Six common deficient items are treated as customer's voice and five system design requirements are proposed in consultation with experts to satisfy the customer requirements. To address the issue of system design, commonly adopted decision-making techniques known as **Quality Function Deployment (QFD)** has been adopted in Chapter 5. The key findings in this chapter can be summarized as follows:

1. It is observed that the design requirements such as '**Opportunities for knowledge up-gradation'** may be given maximum weightage while designing the policy for a TES followed by the attributes of '**Continuous evaluation**' so that requirements of important stakeholders such as students, alumni, parents and recruiters can be satisfied. The '**Management responsibility**' showed the lowest rating in this case.

2. The other design requirements such as **'Industry-Institute Interface'** and **'Technology driven teaching aids'** can be taken up simultaneously in the next phase of the quality implementation program since both of them showed almost the same normalized rating.
3. Although **'Management responsibility'** has emerged as the least important design requirements but its attributes are also vital for system design in the overall implementation of the quality implement program in a TES.

Benchmarking is one of the best ways of comparing an organization with the best in the market place. It helps to look at current operational strategies and methods of the organization for improving quality of services so that brand equity and sustenance in business can be ensured. Therefore, the technical institutions in India based on their efficiency score are ranked in Chapter 6. Technical education exhibit highly process oriented and multi-stakeholder situation leading to difficulty in aggregating the functional variables (inputs and outputs) for the evaluation of education quality. Therefore, it is desirable to use a tool that is capable of relating customers' perception (input) to the desired performance (output) of the TES and makes strategic decision-making easier. **Data Envelopment Analysis (DEA)** is most suitable methodology for this purpose as it aggregates the multiple input and multiple output components in order to obtain an overall performance measure through the comparison of a group of Decision Making Units (DMUs) by finding out the relative efficiency of the units under consideration.

Twenty Indian institutions offering technical education in Undergraduate, Postgraduate, and Research level have been considered as the DMUs in this analysis. They happen to be top ranked institutions as per a survey conducted by a leading weekly magazine [INDIA TODAY, 06 June, 2006] in association with a professional surveying agency. The responses of the stakeholders such as students, alumni, parents and recruiters for their perceptions and expectations under each item are collected through a structured questionnaire survey for

twenty technical institutions (DMUs) on **twenty-eight 'EduQUAL' items**. The analysis has been carried out both using **CRS** and **VRS models** of DEA. The relative efficiencies of the above two models are also compared with the ranking of the surveying agent. The major findings can be summarized as follows.

1. It is observed from CRS model of DEA that eight DMUs out of twenty DMUs have emerged as benchmarking units for the other twelve DMUs. The benchmarking units are listed as DMU_6, DMU_7, DMU_8, DMU_9, DMU_{10}, DMU_{11}, DMU_{12} and DMU_{13}.
2. In VRS model, only two DMUs viz., DMU_5 and DMU_{18} are found to be the DEA-inefficient units.
3. It is also noted that DMU_5 and DMU_{18} show the lowest technical efficiency score both in CRS and VRS model.
4. As the average technical efficiency score of the DMUs in CRS model is 0.934, it suggests that plenty of scope exists for improvements in Indian technical institutions. The average technical efficiency of DMUs in VRS model is 0.982.
5. The correlation coefficient between the two DEA rankings using CRS and VRS models show an average degree of association (r = 0.511773). The paired two-sample t-test indicates that there is a significant difference between the efficiency scores obtained through CRS and VRS models.

The benchmarking institutions found in this study possess few specific characteristics favourable for imparting quality education. These institutions have developed sufficient expertise and competence through experience, experimentation and feedback from market over the years. The most important factor for imparting quality education is the superior level of inputs and dedicated highly qualified, knowledgeable and experienced faculties. Enormous public funding, generation of funds through higher degree of consultancy and industry collaboration activities, continuing education and financial assistance by alumni help to acquire best infrastructure facilities, modern and sophisticated

instruments, IT facilities and library up-gradation leading to facilitate improving infrastructure and personality development.

It has been argued that evaluation of online service quality must be different from traditional service quality. Therefore, a methodology for evaluation on-line service quality has been demonstrated in Chapter 7 and applied to Internet banking functioning in India from customer's perspective. This helps to gain a richer understanding of how Internet affects service quality in the Indian banking sector and provide useful recommendations to the bankers for improving it. Based on the literature review, seven online service quality dimensions such as **reliability, accessibility, user friendliness, privacy/security, efficiency, responsiveness** and **fulfillment** are suggested which may be treated as the most important dimensions in Internet banking for evaluation of customer perceived service quality. A questionnaire survey is conducted to determine the relationships between the dimensions of internet banking and the overall service quality. To gain a deeper understanding between the overall service quality of the Internet banking and the identified dimensions, correlation and regression analysis has been conducted. The important findings can be summarized as follows:

1. A framework to illustrate the overall service quality of the Internet banking in relation to customers' and providers' perspective has been suggested.
2. The seven dimensions identified above are validated through principal component factor analysis.
3. The correlation analysis of the dimensions indicates that the highest degree of positive correlation exists between the dimensions 'Fulfillment' and 'Responsiveness'. A high degree of significant positive correlation is also observed between 'Accessibility' and 'Reliability' and 'Security' and 'User friendliness'.
4. As two out of seven dimensions (Privacy/Security and Fulfillment) are not statistically significant ($P<0.05$), it indicates that further improvement in these dimensions is absolutely essential. In addition, the dimension

'Responsiveness' has the greatest influence on overall service quality followed by 'Reliability' and 'Accessibility'.

5. Two-sample t-tests have been conducted taking the responses of male and female respondents classified as per professions, age group and income group. The results show that the business class differs from other classes in their perception about the service quality of Internet banking.

8.3 Contribution of the Research Work

Some of the major contributions of the dissertation work are summarized as follows:

1. Through an exhaustive literature survey on the implementation pattern of TQM both in manufacturing and service sector, it has been established that only twenty one percent of the total articles surveyed covers the service sector implementing TQM. The low implementation of TQM in service sector may be attributed to the intangibility and the human behavioral aspects associated with it. Therefore, service sector has emerged as a domain where exhaustive researches can be carried out.
2. In education sector, persistence of intangibility and lack of physical evidence of service makes perception of the service quality a complex composition and its analysis becomes difficult. TES is characterized by a multiple stakeholder situation with different backgrounds and varied behavioral patterns. In order to evaluate the quality at an aggregate level fitting to most of the important stakeholders, a new instrument, known as 'EduQUAL', has been proposed for measuring technical education quality in India.
3. Modeling customer evaluation of service quality applying neural network resulted in the uniform construct of education quality that suit all the stakeholders. This will help the administrators of TES to focus on these quality items for improving quality of service.
4. In order to improve the quality in technical education in India, system design requirements to address six identified deficient items by the

stakeholders are prioritized using QFD so that administrator of TES can implement the quality program in a systematic manner.

5. Stakeholder's expectations (input) and perceptions (output) obtained through administrating questionnaire based on 'EduQUAL' are analyzed to find the relative efficiencies of the various technical institutions through DEA. The results indicated the inefficient institutions could improve quality and become competitive by adjusting the slack values between the inefficient and the benchmarked units. This analysis is particularly useful for the different technical institutions to find out the inefficiencies in their institute and the peer institute to whom they can follow to become the efficient institute.
6. Survey conducted to assess service quality of Internet banking from customer's perspective are statistically analyzed to provide guidelines to bankers and researchers for understanding how Internet affects service quality in Indian context. Useful recommendations for the bankers in respect to improvement of the service quality have been extracted.

8.4 Recommendations

This study demonstrates the methodology for modeling customer evaluation of service quality in education sector at an aggregate level. The approach is quite general and can be applied to any specific organisation. However, we recommend identification of customers at the first step and then meticulously finding out their requirements. The next step is to design a measuring instrument for particular application and should be used only after validating through statistical tests. In the third step, appropriate neural network model may be developed and sensitivity analysis of the model to be carried out for identification of current deficient items. The following recommendations are made for application of the proposed approaches:

1. Education sector is characterized as multiple stakeholder sectors with different backgrounds and varied behavioral patterns. Therefore, it poses difficulty to the administrators to evaluate quality at aggregate level fitting

to most of the important stakeholders. To this end, an instrument, known as 'EduQUAL', for measuring service quality in Indian technical institutions have been suggested which can be applied by the administrators of TES to evaluate of service quality of technical institutions through a set of quality items.

2. Most of the time, the administrators face difficulties in implementing all the quality items of a measuring instrument such as 'EduQUAL', to improve the service quality. In order to find out effect of different quality items currently existing in the system on overall satisfaction level of the customers, sensitivity analysis of quality evaluation model based on neural network is emphasized. The uniform construct for TES in India emerged in this research consists of six items if the expectations and perceptions of stakeholders such as students, alumni, parent and recruiters are considered. The methodology is quite efficient, simple and generic in nature and can be applied to any service setting for identification of existing bottlenecks.
3. Due to various constraints, all the requirement of the stakeholders needed for quality improvement cannot be implemented simultaneously. Therefore, it is of prime importance for administrators of TES to prioritize the system design requirements that bears in its ability to satisfy the customers. To address these issues, the administrators must identify the quality items that need to be improved on a priority basis and then prioritize the design requirements that satisfy such identified quality items.
4. The methodology outlined for ranking technical institutions based on their relative efficiencies is highly useful for inefficient institutions to follow the best practices. The methodology is quite general and can be applied to any service sector.
5. The survey of Indian customers for the quality of Internet banking in this dissertation work reveal seven important dimensions. Statistical results demonstrated that some of the dimensions like 'privacy/security' and 'fulfillment' need to be emphasized more by the bankers in order to

provide better service to the customers. Currently bankers are employing a range of security features such as firewall, 128-bit Secure Socket Layer (SSL), two-level of passwords system and secured funds transfer in Internet banking in order to assure confidence of customers in regard to safety and privacy of their personal information. IT technology is progressing at a fast rate and so the web crime is increasing at an alarming rate. Therefore, it is recommended that the bankers must employ latest technology for providing security and privacy of the customers. The timely up gradation of the technology by the bankers can check the web crime to a great extent.

8.5 Limitations

The following limitations of this research are worth mentioning.

1. Although cross-sectional survey of quality in technical institutions has been carried out with statistically significant response rate but it is not enough to generalize the results in a vast country like India.
2. The study can be extended to a larger sample with emphasis on weightage of each item of the survey instrument and relative importance of dimensions.
3. For evaluation of quality in TES, only expectations and perceptions of the stakeholders are considered. Other behavioral pattern of stakeholders may influence the service quality evaluation differently. For example, the state of mind at the time of purchase influences impromptu decision to avail a particular service plays a major role in evaluating service quality.
4. Benchmarking of Indian technical institutions has been carried out using the expectations and perceptions data of the stakeholders for only twenty institutions. Large number of institutions (DMUs) can be considered for obtaining richer insight to the problem.
5. Assumption of linear relationship between expectations and perceptions in DEA approach may be misleading at times.

6. Other aspects of quality like infrastructure, motivation of faculties, funds generation and management policy can also be taken up for detail analysis of quality in TES using DEA.
7. In this research, only 1143 responses have been considered to suggest the seven dimensions of service quality of Internet banking in India. Large sample of respondents through cross-sectional questionnaire survey may produce better results.

8.6 Scope for Further Research

Any research of this nature, particularly in the field of quality in service sector is required to be extended considering the limitations of the study. Some of these areas where further research is required to be carried out to tackle the limitations of the proposed approaches are as follows:

1. A large number of samples from the customers may be collected to have better understanding of quality characteristics in service sectors.
2. For benchmarking of institutions, other important facts such as infrastructure, motivation of faculties, funds generation and administration of the institutions along with the expectations and perceptions of the stakeholders may be adopted in future for further research.
3. Applying the same methodologies effectively in other service sectors such as health care, tourism, hotels and restaurants, transportation, repair and maintenance shop, information service and recreational services may carry out extension of this research.

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Appendices

Appendix 3.1

Sample Questionnaire for Service Quality Assessment in TES

1-very low; 7- very high
Tick a number under each item for expectations as well perceptions

Items	Expectation	Perceptions
1. Problem solving skill	1 2 3 4 5 6 7	1 2 3 4 5 6 7
2. Well equipped Laboratories with modern facilities	1 2 3 4 5 6 7	1 2 3 4 5 6 7
3. Training on state of the art technology	1 2 3 4 5 6 7	1 2 3 4 5 6 7
4. Effective office management	1 2 3 4 5 6 7	1 2 3 4 5 6 7
5. Knowledge of official procedures	1 2 3 4 5 6 7	1 2 3 4 5 6 7
6. Cleanliness, orderliness, systematic and Methodical	1 2 3 4 5 6 7	1 2 3 4 5 6 7
7. Adequate facilities/infrastructure to render service	1 2 3 4 5 6 7	1 2 3 4 5 6 7
8. Faculty expertise	1 2 3 4 5 6 7	1 2 3 4 5 6 7
9. Adequacy of subject teacher	1 2 3 4 5 6 7	1 2 3 4 5 6 7
10.Good communication skill of academic staff	1 2 3 4 5 6 7	1 2 3 4 5 6 7
11. Comprehensive learning resources	1 2 3 4 5 6 7	1 2 3 4 5 6 7
12. Training in a well equipped communication laboratory	1 2 3 4 5 6 7	1 2 3 4 5 6 7
13. Adaptability to modern techniques	1 2 3 4 5 6 7	1 2 3 4 5 6 7
14. Design of course structure based on job Requirement	1 2 3 4 5 6 7	1 2 3 4 5 6 7
15. Adequacy of supporting staff	1 2 3 4 5 6 7	1 2 3 4 5 6 7
16. Instructional/educational leadership	1 2 3 4 5 6 7	1 2 3 4 5 6 7
17. Effective classroom management	1 2 3 4 5 6 7	1 2 3 4 5 6 7
18. Opportunities for campus training and Placement	1 2 3 4 5 6 7	1 2 3 4 5 6 7
19. Information sharing and exchange	1 2 3 4 5 6 7	1 2 3 4 5 6 7
20. In-service training and development of supporting staff	1 2 3 4 5 6 7	1 2 3 4 5 6 7
21. Faculty's rapport with student	1 2 3 4 5 6 7	1 2 3 4 5 6 7
22. Autonomy/freedom of work	1 2 3 4 5 6 7	1 2 3 4 5 6 7
23. Recognition of students/ faculty/staff	1 2 3 4 5 6 7	1 2 3 4 5 6 7
24. Courteous and willingness to help	1 2 3 4 5 6 7	1 2 3 4 5 6 7
25. Appropriate classroom hours	1 2 3 4 5 6 7	1 2 3 4 5 6 7
26. Maximum learning time	1 2 3 4 5 6 7	1 2 3 4 5 6 7
27. Academic, residential and recreational facilities	1 2 3 4 5 6 7	1 2 3 4 5 6 7

28. Aesthetic view of facilities	1 2 3 4 5 6 7	1 2 3 4 5 6 7
29. Encouragement for sports, games and cultural activities	1 2 3 4 5 6 7	1 2 3 4 5 6 7
30. Enhancement of knowledge	1 2 3 4 5 6 7	1 2 3 4 5 6 7
31. Extra academic activities	1 2 3 4 5 6 7	1 2 3 4 5 6 7
32. Adherence to schedule	1 2 3 4 5 6 7	1 2 3 4 5 6 7
33. Clarity of course objectives	1 2 3 4 5 6 7	1 2 3 4 5 6 7
34. Adherence to course objectives	1 2 3 4 5 6 7	1 2 3 4 5 6 7
35. Practical orientation in education	1 2 3 4 5 6 7	1 2 3 4 5 6 7
36. Faculty available regularly for students' consultation	1 2 3 4 5 6 7	1 2 3 4 5 6 7
37. Prompt service of the supporting staff	1 2 3 4 5 6 7	1 2 3 4 5 6 7
38. Ease of access to the institution	1 2 3 4 5 6 7	1 2 3 4 5 6 7
39. Close supervision of students' work	1 2 3 4 5 6 7	1 2 3 4 5 6 7
40. Proper monitoring system and evaluation procedure	1 2 3 4 5 6 7	1 2 3 4 5 6 7
41. Record keeping on performances	1 2 3 4 5 6 7	1 2 3 4 5 6 7
42. Transparency of official procedure, norms and rules	1 2 3 4 5 6 7	1 2 3 4 5 6 7
43. Sense of social obligation	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Appendix 3.2

Principal Component Factor Analysis

Terminologies of Factor Analysis

Factor Loadings, $L_i(j)$

It is the matrix representing the correlation between different combinations of variables and factors. $L_i(j)$ is the factor loading of the variable j on the factor i, where i =1, 2, 3, ….., n and j = 1, 2, 3, ….., n.

Communality, h_i^2

It is the sum of squares of the factor loadings of the variable I on all factors:

$$h_i^2 = \sum_{j=1}^{n} L_{ij}^2$$

Eigenvalue

It is the sum of squares of the factor loadings of all variables on a factor.

$$\text{Eigenvalue of the factor } j = \sum_{i=1}^{n} L_{ij}^2$$

Note: The sum of the eigenvalues of all factors (if no factor is dropped) is equal to the sum of the communalities of all variables.

Factor Rotation:

Since the original loadings may not be readily interpretable, the usual practice is to rotate them until a 'simple structure' is achieved. A simple structure means that each variable has very high factor loadings (as high as 1) on one of the factors and very low factor loadings (as low as 0) on the other factors. The communalities of each variable before and after factor rotation will be the same.

Significant Number of Factors

The main objective of factor analysis is to group the given set of input variables into minimal number of factors with the maximum capability of extracting information with the reduced set of factors. There are basically two criteria to determine the number of factors to be retained for future study:

Minimum Eigenvalue Criterion: If the eigenvalue (sum of squares of the factor loadings of all variables on a factor) of a factor is more than or equal to 1, then that factor is to be retained; otherwise, that factor is to be dropped.

Scree Plot Criterion: It is a plot of the eigenvalues of the factors by taking the factor number on X-axis and the eigenvalues on Y-axis. Then, identify the factor number at which the slope of the line connecting the points changes from steep to a gradual trailing off towards the right of the identified factor number. Such change in slope in the graph is known as 'scree' and the point is known as 'scree point'. The factors which are marked up to the right of the scree point are to be dropped from the study.

Factor Scores:

Though a factor is not visible like an original input variable, it is still a variable which can be used to find the scores for respondents. At the initial stage, the respondents assign scores for the variables. After performing factor analysis, each factor assigns a score for each respondent. Such scores are called 'factor scores'.

The expression to compute the factor score of a respondent by the factor *k* is shown below. By substituting the standardized values of the input variables assigned by a respondent in this expression, the factor score of that respondent can be obtained:

$$F_k = w_{1k} X_1 + w_{2k} X_2 + w_{3k} X_3 + \cdots + w_{ik} X_i + \cdots + w_{nk} X_n = \sum_{i=1}^{n} w_{ik} X_i$$

Where w_{ik} is the weight of the input variable X_i in the linear composite of the factor, *k*, for *k* = 1, 2, 3, ….., n.

Steps of Principal Component Method

This method maximizes the sum of squares of loadings of each identified factor. This is a popular technique which determines loadings of variables on different factors by using the standard normal values of the observations of the original (input) variables.

The steps of the principal components analysis are summarized as follows:

Step-1: In the original sets of observation

$$[a_{ij}];\ \ i = 1, 2, 3, \cdots, m \quad and \ \ j = 1, 2, 3, \cdots, n.$$

Step-2: Find the standardized sets of observations $[z_{ij}]$ from $[a_{ij}]$ using the following formula:

$$z_{ij} = \frac{a_{ij} - \overline{X_j}}{\sigma_j}; \quad i = 1, 2, 3, \cdots, m \text{ and } j = 1, 2, 3, \cdots, n$$

where $[z_{ij}]$ is the standardized observation of the ith original observation under the variable j and σ_j is the standard deviation of the original observations of the variable j.

Step-3: Determine the weights of the different linear composites of factors $[w_{ij}]$ such that the variance of the unstandardized factor scores of the entire set of observations is maximal. These weights are nothing but directional cosines of the respective vectors.

Step-4: Find the unstandardized factor scores using the following formula:

$$[f_{ij}]_{m\times n} = [z_{ij}]_{m\times n} \times [w_{ij}]_{n\times n}$$

Step-5: Find the loadings of the variables on the factors L_{ij} is the correlation coefficient between the values in column i of matrix $[z_{ij}]$ and that of column j of the matrix $[f_{ij}]$ for $i = 1, 2, 3, \cdots, n$ and $j = 1, 2, 3, \cdots, n$

Step-6: Find the standardized factor scores using the following formula:

$$S_{ij} = \frac{f_{ij} - \overline{M_j}}{s_j}; \quad i = 1, 2, 3, \cdots, m \text{ and } j = 1, 2, 3, \cdots, n$$

Where S_{ij} the standardized factor is score of the ith set of observations on the factor j; $\overline{M}$, the mean of the unstandardized factor scores of the factor j and s_j is the standard deviation of the unstandardized factor scores of the factor j.

Step-7: Find the prediction of the standardized original observations using the following formula:

$$[Z_{ij}]_{m\times n} = [S_{ij}]_{m\times n} \times [L_{ij}]_{n\times n}$$

Step-8: Find the sum of squires of loadings of each column- j (principal component- j /factor- j) which is known as eigenvalue of that column j .

Step-9: Drop insignificant principal components which have eigenvalues less than 1. Let the number of principal components retained be X .

Step-10: Perform the rotation of the retained principal components for better interpretation. The rotation can be done by 'varimax rotation method' or 'promax rotation method'.

Step-11: Assign each variable to the principal component (factor), with which it has the maximum absolute loading (irrespective of sign).

Step-12: Find the sum of squares of loadings for each variable i (row i). It is denoted by h_1^2 . Also, find the common variance, whose formula is given below:

$$Common\ Variance = \sum_{i=1}^{X} h_1^2 \ ;$$

where X is the number of retained principal components.

Step-13: For each retained principal component, $k\,(k = 1, 2, 3, \cdots, X)$, find the following and state inferences:

$$\text{Proportion of total variance of the principal component } k = \frac{Eigenvalue\ \ of\ \ principal\ \ component\ \ k}{Total\ \ \text{variance}}$$

Where the total variance is equal to the number of variables, n . Also,

$$\text{Proportion of common variance of the principal component } k = \frac{Eigenvalue\ \ of\ \ principal\ \ component\ \ k}{Common\ \ \text{variance}}$$

$$= \frac{Eigenvalue\ \ of\ \ principal\ \ component\ \ k}{Sum\ \ of\ \ the\ \ eigenvalues\ \ of\ \ the\ \ retained\ \ principal\ \ component}$$

Appendix 3.3

Varimax Method of Factor Rotation

Steps of Varimax Method of Factor Rotation:

Since the original loadings may not be readily interpretable, the usual practice is to rotate them until a 'simple structure' is achieved.

Kaiser (1958) has suggested an analytical measure of 'simple structure' known as the Varimax rotation. It is denoted by:

$$\mathrm{V} = \frac{1}{p}\sum_{j=1}^{m}(\mathrm{var}\,iance\ of\ \ squares\ \ of\,(scaled\,)\,loadings\ \ for\ jth\ factor\,)$$

Where p×m is a matrix of estimated factor loadings obtained.

The steps of varimax rotation method for two factors are presented below:

Step-1: Input the factor loading matrix. Number of variables = n. Number of principal components (factors) = 2. Angle of rotation $=\theta$.

Step-2: Plot the factor loadings on a two-dimensional space, $F_1 - F_2$ plane, where F_1 and F_2 are factor-1 and factor-2 respectively. Let ø be the angle between the nearest axis (F'_1 or F'_2) and each vector of factor loadings.

Step-3: Rotate the $F_1 - F_2$ plane by an angle such that the factor loadings are revised to have a simple structure. A simple structure means that each variable has very high factor loading (as high as 1) on one of the factors and very low factor loading (as low as 0) on other factors. Let the rotated plane be $F_1^{'} - F_2^{'}$.

Step-4: Set variable number, $i = 1$.

Step-5: Let a_i and b_i be the factor loadings of the variable i on F_1 and F_2, respectively. Find the magnitude of the vector C_i of the factor loadings of the variable i, using the following formula:

$$C_i = (a_i^2 - b_i^2)^{0.5}$$

Let the angle of the vector of factor loadings with the nearest part (positive side and negative side) of F_1 axis be α.

Step-6: Find $\cos\phi$ and treat it as the factor loading on the nearest axis ($a_i^{'}$ if the nearest axis as explained in step-1 is $F_1^{'}$ axis, $b_i^{'}$ if the nearest axis is $F_2^{'}$ axis). Fix the sign of the revised loading depending on the side of the factor (plus for positive side and minus for negative side).

Step-7: Find $\cos(90-\phi)$ and treat it as the factor loading on the other axis ($b_i^{'}$ if the nearest axis as explained in step-1 is $F_1^{'}$ axis, $a_i^{'}$ if the nearest axis is $F_2^{'}$ axis). Fix the sign of the revised loading depending on the side of the factor (plus for positive side and minus for negative side).

Step-8: $i = i + 1$

Step-9: If $i \leq n$, then go to step-5; otherwise go to step-10.

Step-10: Print the revised factor loading matrix.

Step-11: Group variables into factors and make inferences

Appendix 4.1

An Algorithm for Generalized Delta-Rule

Step 1: Randomly assign values between 0 and 1 to weights v_{ij} and w_{jk}. The internal threshold values are assigned as follows:

Input layer threshold, $T_{1i} = 0$;

All hidden and output layer threshold, $T_{2j} = T_{3k} = 1$

Step 2: Introduce the input Ii into the neural network and calculate the output from the first layer according to the equations:

$x_i = I_i + T_{1i} = I_i + 0 = I_i$ .....(1)

Activation function, $a_i = f(x_i) = \dfrac{1}{1 + e^{-x_i}}$ .....(2)

Step 3: Knowing the output from the first layer, calculate outputs from the second layer using the equation:

$$b_j = f\left(\sum_{i=1}^{L} (v_{ij} a_i) + T_{2j} \right) \qquad \text{.....(3)}$$

Where b_i bias function

Step 4: Knowing the output from the second layer, calculate the result from the output layer(3rd layer) according to the equation:

$$c_k = f\left(\sum_{i=1}^{m} (w_{jk} b_j) + T_{3k} \right) \qquad \text{.....(4)}$$

Where $f(\ )$ is the sigmoid function T_{3k} acts as a bias function added to the weighted input.

Step 5: Continue step 1-4 for P number of training patterns presented to the input layer. Calculate the mean square error, E according to the following formula:

$$E = \sum_{p=1}^{p} \sum_{k=1}^{n} (d_k^p - c_k^p)^2 \qquad \text{.....(5)}$$

where n is the number of nodes in the output layer d^p_k is the desired output value from the kth node and p^{th} training c^p_k is the actual output value from the kth node and p^{th} training

Step 6: knowing the pth pattern, calculate, δ^p_{3k} the gradient-descent term for the kth node in the output layer (layer 3) for training pattern p.

$$\delta^p_{3k} = (d^p_k - c^p_k)\frac{\partial f}{\partial x_k} \qquad \text{.....(6)}$$

Where $x^p_k = \sum_j w^p_{jk} b^p_k + T^p_{3k}$

f( ) is the sigmoid function,

$$f(x) = \frac{1}{1+e^{-x}} \qquad \text{.....(7)}$$

and its partial derivative is:

$$\frac{\partial f}{\partial x_k} = \frac{e^{-x_i}}{(1+e^{-x_i})^2} \qquad \text{.....(8)}$$

Step 7: Again knowing the pth pattern, calculate, δ^p_{2j} the gradient-descent term for the jth node on the hidden layer (layer 2). So,

$$\delta^p_{2j} = \left(\sum_k \delta^p_{3k}\, w^p_{jk}\right)\frac{\partial f}{\partial x_j} \qquad \text{.....(9)}$$

Where the subscript k denotes a node in the output layer and x_j is defined by

$$x^p_{2j} = \sum_i v^p_{ij}\, a^p_i + \mathrm{T}^{\mathrm{p}}_{2\mathrm{j}} \qquad \text{.....(10)}$$

And the partial derivative of the sigmoid function is:

$$\frac{\partial f}{\partial x_j} = \frac{e^{-x}}{(1+e^{-x})^2} \qquad \text{.....(11)}$$

Step 8: knowing $\delta_{2}{}^{p}{}_{j}$ for hidden layer and δ_{3k}^{p} for the output layer, calculate the weight changes using the equations:

$$\Delta \mathrm{v}_{\mathrm{ij,new}}^{\mathrm{p}} = \eta \delta_{2j}^{p} \; a_{j}^{p} + \alpha \Delta \mathrm{v}_{\mathrm{ij}}^{\mathrm{p-1}} \qquad \text{.....(12)}$$

$$\Delta \mathrm{w}_{\mathrm{jk,new}}^{\mathrm{p}} = \eta \delta_{3k}^{p} \; b_{j}^{p} + \alpha \Delta \mathrm{w}_{\mathrm{jk}}^{\mathrm{p-1}} \qquad \text{.....(13)}$$

where η is the learning rate and α is the momentum coefficient Momentum is simply an added weight used to speed up the training rate. The value usually 0<α<1.

Step 9: Knowing the weight changes, update the weights according to the equations:

$$w_{jk,new}^{p} = w_{jk}^{p-1} + \Delta w_{jk,new}^{p} \qquad \text{.....(14)}$$

$$\mathrm{v}_{ij,new}^{p} = \mathrm{v}_{ij}^{p-1} + \Delta \mathrm{v}_{ij,new}^{p} \qquad \text{.....(15)}$$

Step 10: Repeat steps 2-9 for all training patterns until the squared error is zero or sufficiently low.

Appendix 6.1

A Sample Questionnaire for Ranking of Technical Institutions

Scale used 1-7: (1, strongly disagree and 7, strongly agree)
The respondents are required to rate for Twenty Technical Institutes for each EduQUAL item

EduQUAL Items	Expectation	Perceptions
1. Training on state-of-the art technology	1 2 3 4 5 6 7	1 2 3 4 5 6 7
2. Practical orientation in education.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
3. Adaptability to modern techniques	1 2 3 4 5 6 7	1 2 3 4 5 6 7
4. Design of course structure based on job requirements.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
5. Problem solving skills.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
6. Sense of social obligation.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
7. Prompt service at service departments.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
8. Courteousness and willing to help.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
9. Cleanliness, orderliness, systematic and methodical	1 2 3 4 5 6 7	1 2 3 4 5 6 7
10. Transparency of official procedure, norms and rules.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
11. Adequate facilities/infrastructure to render service.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
12. Well equipped laboratories with modern facilities.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
13. Comprehensive learning resources.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
14. Academic, residential and recreational facilities	1 2 3 4 5 6 7	1 2 3 4 5 6 7
15. Aesthetic views of facilities.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
16. Training in a well equipped communication laboratory	1 2 3 4 5 6 7	1 2 3 4 5 6 7
17. Opportunities for campus training and placement	1 2 3 4 5 6 7	1 2 3 4 5 6 7
18. Effective classroom management.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
19. Encouragement for sports games and cultural activities	1 2 3 4 5 6 7	1 2 3 4 5 6 7
20. Enhancement of knowledge.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
21. Adherence to schedule.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
22. Extra academic activities.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
23. Recognition of the students	1 2 3 4 5 6 7	1 2 3 4 5 6 7
24. Adequacy of subject teachers.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
25. Available regularly for students' consultation.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
26. Close supervision of students work.	1 2 3 4 5 6 7	1 2 3 4 5 6 7
27. Expertise in subjects and well organized lectures	1 2 3 4 5 6 7	1 2 3 4 5 6 7
28. Good communication skill of academic staff.	1 2 3 4 5 6 7	1 2 3 4 5 6 7

Appendix 7.1

A Sample Questionnaire for Assessment of Service Quality in Internet Banking

Part-I

Please type 'Y' in the appropriate box.

1. **Age**
   - (i) Up to 20 years ☐ (ii) 20-30 years ☐
   - (iii) 30-40 years ☐ (iv) 40-50 years ☐
   - (v) 50-60 years ☐ (vi) 60 years and above ☐
2. **Gender**
   - (i) Male ☐ (ii) Female ☐
3. **Residential Area**
   - (i) Urban ☐ (ii) Rural ☐
4. **Education**
   - (i) Up to high school ☐ (ii) Bachelor degree ☐
   - (iii) Master degree ☐ (iv) Doctor Degree ☐
5. **Profession**
   - (i) Students/faculty ☐ (ii) Employee (Govt. /private) ☐
   - (iii) Employee (industry) ☐ (iv) Retired person ☐
   - (v) Business ☐ (vi) Others ☐
6. **Income**
   - (i) Less than Rs. 15,000 ☐ (ii) 15,000 to 50,000 ☐
   - (iii) 50,000 to 1, 00,000 ☐ (iv) More than 1, 00,000 ☐
7. **Level of Computer Literacy**
   - (i) Don't know any thing at all about computer ☐
   - (ii) Have some knowledge about it but not enough to use computer ☐
   - (iii) Have more knowledge about it and be able to use them ☐
   - (iv) Know lot about computer ☐
8. **How long have you been using Internet banking?**
   - (i) Less than 1 year ☐ (ii) 1-2 years ☐
   - (iii) 2-3 years ☐ (iv) 3-4 years ☐
   - (v) 4 years and more ☐

9. **Duration of access of Internet banking.**

(i) Everyday ☐ (ii) 1 – 7 days ☐

(iii) 7 -15 days ☐ (iv) 15 – 30 days ☐

(v) Occasionally ☐

10. **Which type(s) of service you choose to operate via Internet banking? (You can select more than one option).**

(i) Account enquiry (opening of account/balance/interest) ☐

(ii) Funds transfer (bill payment/reservation in rail and air) ☐

(iii) Insurance premium ☐ (iv) Investments ☐

(v) E- shopping ☐ (vi) Tax-service ☐

(vii) Credit and debit card ☐ (viii) Brokerage ☐

(ix) Foreign exchange trading ☐ (x) Online trading ☐

11. **Are you using only one bank or different banks?**

(i) One bank ☐ (ii) More than one bank ☐

12. **Name(s) of the Banks used**

☐

Part- II

Please assign a number from 1 to 7 in the appropriate box.

1 – Strongly disagree	**2 – Partially disagree**	**3 – Somewhat disagree**
	4 – No opinion	
5 – Somewhat agree	**6 – Partially agree**	**7 – Strongly agree**

1. The web pages are functioning properly ☐
2. The bank's site is running properly all the times ☐
3. Links are problem free, accurate and the pages download quickly ☐
4. Information that is provided is accurate ☐
5. Information content and texts are easy to understand ☐
6. The bank's site has unrestricted access to all financial information ☐
7. The bank provides the updated technology regularly for Internet banking ☐
8. The bank is easy to approach and easy contact ☐
9. The web pages don't freeze after you have put in all you information ☐
10. The bank's site provide information about the transactions and products ☐
11. The website is available in the language you can understand ☐
12. The bank authority care to listen to your queries and meet your personal needs ☐

13. Personalization of bank's site for customers' personal requirement
14. The bank authority care to listen to your queries and meet your personal needs ☐
15. You can rely on the personal information remaining in the register ☐
16. You can rely on bank for not misusing your information ☐
17. The bank's site is secured for your credit card information ☐
18. The bank shows care in how it collects your personal information ☐
19. The bank provides financial security and confidentiality ☐
20. The speed of login of your account is fast ☐
21. Easy to find all information from the bank's website ☐
22. The bank's site is easy to navigate and simple to use ☐
23. It is easy to find policy and notice statement on the bank's site ☐
24. The speed of logout of your account is fast
25. The bank is willing to help customers, provide appropriate information and prompt service ☐
26. You are able to talk to a customer service representative in the bank over telephone ☐
27. Knowledge and skill of the contact personnel ☐
28. Availability of online customer service representatives ☐
29. The bank takes care of problems properly and compensate for the problems they create ☐
30. The bank's site provides a confirmation of the service ordered quickly ☐
31. The bank's site performs the service right at the first time ☐
32. The bank's site does not confuse you in what you want to do. ☐

(a) **Are you satisfied with the services that you are getting from your bank?** ☐

(b) Would you like to add/suggest more quality criteria that will help to satisfy your need when you use Internet banking service?

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Research Publications:

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